REFERENCES

(Asterisks refer to sources of data shown in figure 5.)

quadrangle and part of the Hamburg quadrangle, New Jersey: U.S. Geological Survey

and Knapp, G. N., 1909, Philadelphia, Pennsylvania-New Jersey-Delaware (Norristown Germantown, Chester, and Philadelphia quadrangles): U.S. Geological Survey Geologic

, 1909, Trenton, New Jersey-Pennsylvania: U.S. Geological Survey Geologic Atlas, Fo

Delaware: U.S. Geological Survey Geologic Atlas, Folio 223, 15 p.
Bayley, W. S., Salisbury, R. D., and Kümmel, H. B., 1914, Raritan, New Jersey: U.S. Geological

of Pennsylvania: Pennsylvania Geological Survey, 4th series, Map no. 61, 636 p.
Berg, T. M., Edmunds, W. E., Geyer, A. R., Glover, A. D., Hoskins, D. M., MacLachlan, D. B

Root, S. I., Sevon, W. D., and Socolow, A. A., 1980, Geologic map of Pennsylvania

Harrisburg Pennsulvania Department of Environmental Resources, Pennsylvania Geologi

Bouma, A. H., 1962, Sedimentology of some flysch deposits, a graphic approach to facies

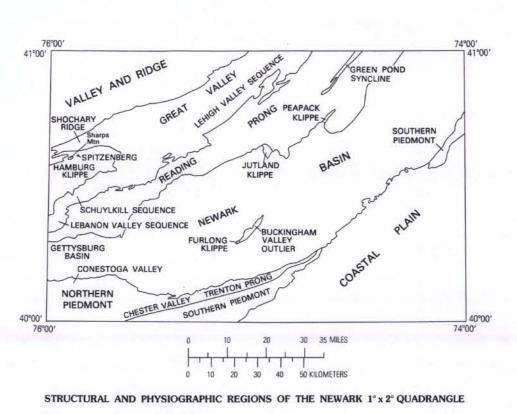
Darton, N. H., 1890, The relation of traps of the Newark System in the New Jersey region: U.S.

Darton, N. H., Bayley, W. S., Salisbury, R. D., and Kümmel, H. B., 1908, Passaic, New Jersey-

Atlas, Folio 162, 24 p.

Survey, 4th series, scale 1:250,000.

American Journal of Science, v. 271, no. 4, p. 333-349.



DESCRIPTION OF MAP UNITS Note: A variety of Holocene deposits and Pleistocene glacial sediments are present throughout the quadrangle, and Pleistocene and Tertiary terrace deposits of gravel, sand, and clay are common along the area of the Fall Line. None of these units are shown on the map.

COASTAL PLAIN The Coastal Plain is a gently seaward-sloping surface on poorly consolidated sediments of Tertiary and 755 m (2,480 ft) in thickness along the coast, and thins to a feather edge along the Fall Line where they

ediments are mostly nonmarine, the overlying units are mostly marginal marine in origin Tch Cohansey Sand (Pliocene (?) and Miocene)—Well-sorted, crossbedded, mediumgrained, partly arkosic quartz sand; some dark, massive, carbonaceous, kaolinitic, and illitic silty clay; crossbedded gravel in channels with pebbles of quartz and quartzite; and minor orphic rock fragments which are less than 5 cm (2 in) in diameter. As much as 46 m (150 ft) thick, thinning toward the Fall Line Kirkwood Formation (Miocene)—Moderately well sorted, fine-grained, micaceous quar sand, locally clayey or silty with local thick beds of clayey silt and fine-pebble gravel. Lower Manasquan Formation (Eocene)—Thick-bedded to massive, silty and clavey glauconitic and quartzose sand; interbedded silty clay and clayey silt. Apatite pellets and siderite fragments locally abundant. 15-61 m (50-195 ft) thick Vincentown Formation (Paleocene)—Partly clayey, glauconitic quartz sand. 15-30 m

locally very silty and clayey glauconite and quartz sand with some phosphate pellets and oone fragments. Lower contact unconformable. About 6 m (20 ft) thick Red Bank Sand (Upper Cretaceous)—Very thick bedded, medium- to coarse-grained fairly indurated, quartz, feldspar, and glauconite sand and fossiliferous sandy silt. As much Navesink Formation (Upper Cretaceous)—Dark-gray, thick-bedded, clayey and silty, suconite sand, with organic matter, pyrite, and local thick shell beds. As much as 14 m Kml Mount Laurel Sand (Upper Cretaceous)—Medium-grained, poorly to moderately sorted, feldspathic quartz sand. Abundant borings filled with glauconite sand and thin-bedded lark, micaceous and carbonaceous silt and clay alternating with medium-bedded, light colored, micaceous, glauconitic quartz sand with discontinuous layers of gray siderite oncretions. As much as 15 m (50 ft) thick Wenonah Formation (Upper Cretaceous)-Generally dark, thick-bedded, fine- to medium-grained, poorly to moderately sorted, carbonaceous, pyritic, very silty and clayey, quartzose glauconite sand. 21–30 m (70–100 ft) thick Marshalltown Formation (Upper Cretaceous)—Dark, fine-grained, massive,

Hornerstown Sand (Paleocene)-Massive, poorly sorted, fine- to medium-graine

fossiliferous, very silty and clayey, quartzose glauconite sand with common mica, feldspar, pyrite, and carbonaceous matter. 5–6 m (15–20 ft) thick Englishtown Formation (Upper Cretaceous)-Light-colored, well-sorted, fine- to edium-grained, crossbedded, glauconitic, feldspathic, and micaceous quartz sand, ar interbedded clayey silt and sand with numerous siderite concretions. 6-46 m (20-150 ft) Woodbury Clay (Upper Cretaceous)-Dark-gray, massive to crudely larr carbonaceous, pyritic, partly glauconitic, micaceous, very clayey (dominantly illitic) silt. As much as 30 m (100 ft) thick Merchantville Formation (Upper Cretaceous)-Dark, clayey, micaceous, quartzose rbonaceous silt with interbedded gravel containing reworked siderite concretions; thick-dded glauconite and quartz sand. 6-30~m (20-100~ft) thick Magothy Formation (Upper Cretaceous)—Dark, micaceous, pyritic, kaolinitic, clavey silt light-colored quartz sand with large lignitized logs. Lower contact is unconfor but is buried by surficial deposits and precise location is poorly known on Staten Island and in Brooklyn, N.Y. 3-61 m (10-200 ft) thick Raritan Formation (Upper Cretaceous)—Massive crosshedded quartz sand: thick-

bedded clayey silt; laminated clay and silt; and minor gravel. About 61 m (200 ft) thick Potomac Formation (Upper and Lower Cretaceous)—Moderately well sorted edded, quartzose sand; gravelly sand with quartz and quartzite pebbles as much as 13 cm (5 in) long; and black, red, white, and yellow, massive, kaolinitic and illitic, crudely stratified, lenticular clay. 76–244 m (250–800 ft) thick. Lower contact unconformable All Coastal Plain sediments (Tertiary and Cretaceous)—Shown in cross section only.

NEWARK AND GETTYSBURG BASINS The Newark basin, and west of the Schuylkill River, the Gettysburg basin, form a rolling lowland underlain a thick succession of sedimentary rocks and basalt flows of Early Jurassic and Late Triassic age. Jurassic liabase dikes, sills, and stocks cut and metamorphose older rocks in the basin. The rocks generally dip gently to moderately to the north toward a large fault zone that forms the basin boundary, although many pen folds with axes at high angles to the strike of the faults have been mapped. The ward-thickening wedge with a composite thickness that may exceed 10,000 m (33,000 ft); however, not all of the units are preserved in one area. Several generations of folds may affect the rocks of the basin, out do not appear to affect the older pre-Triassic rocks outside the basin. The basin may have formed as a pull-apart structure with significant strike-slip movement along the larger faults. This could account or local horsts and grabens within the basin, possible sequential development of different parts of the basin, the compressional regime that produced the folds and local thrust faults, as well as decoupling of the folds within the basin from structures outside the basin. Some of the gently dipping listric normal faults may represent reactivated segments of Paleozoic thrust faults, but with the opposite sense of movement. imestone conglomerate (Rcl), quartzite conglomerate (Rcq), and unclassified conglomerate (Rc) may be partly Jurassic in age. Figure 1 shows stratigraphic and intrusive relationships.

Diabase (Lower Jurassic)—Dikes, sills, and sill-like intrusives. Dark-gray to black, fineto coarse-grained (except very fine to fine-grained near chilled borders), diabase composed largely of calcic plagioclase and augite. Some of the dikes are several miles long and as much as 0.8 km (0.5 mi) wide; some may have been intruded along faults. Generally deeply weathered. Larger bodies, as much as 520 m (1,700 ft) thick, interpreted as sills or discordant sheets with oval or ringlike outcrop patterns. Shales and siltstones surrounding these bodies have been thermally metamorphosed to a purplish-red, light gray, and dark-gray, indurated, brittle, and fine-grained hornfels with quartz, plagioclase, sericite, biotite, cordierite, epidote, chlorite, magnetite, homblende, pyroxene, tourmaline nepheline, cancrinite, and zeolite in a zone averaging about 610 m (2,000 ft) wide. The width of this zone depends on the thickness of the intrusive, its topographic expression,

NEWARK SUPERGROUP* Conglomerate (Lower Jurassic)—Generally poorly exposed conglomerate and nglomeratic sandstone with clasts of quartz, sandstone, conglomerate, granit metamorphic rocks, limestone, and basalt; clasts may be more than 15 cm (6 in) in iameter. Overlies Boonton Formation, Hook Mountain Basalt, and Towaco Formation Jb Boonton Formation of the Brunswick Group (Lower Jurassic)—Lower part is red, gray, brown, and black, blocky, partly dolomitic siltstone; locally contains hopper (salt cry casts pseudomorphic after gypsum, glauberite, and halite. Overlain by red. well-bedder and thick-bedded siltstone and sandstone and thin beds of gray-green siltstone. Bed of nicrolaminated, gray, calcareous siltstone with fossil fish near the top, 1 m (3.3 ft) thick with thin, gray and brown pebble-conglomerate beds as much as 0.5 m (1.6 ft) thick sequences of red-, gray-, and brown-matrix conglomerate and breccia. More than 500 m (1,640 ft) thick Hook Mountain Basalt of the Brunswick Group (Lower Jurassic)—Two tholeiitic basalt flows composed mainly of aphanitic to finely crystalline plagioclase and augite. In places,

Towaco Formation of the Brunswick Group (Lower Jurassic)—Red, gray, and black, fine- to coarse-grained sandstone, siltstone, and conglomerate in fining-upward cycles Medial black and gray, microlaminated, calcareous siltstone containing diagnostic pollen ish, and dinosaurs. Cycles average about 35 m (115 ft) in thickness with maximum Preakness Basalt of the Brunswick Group (Lower Jurassic)—At least three tholeiltic salt flows, with some pillows and basaltic breccia resembling aa. Columnar with characteristic platy prismatic joint pattern. Locally, thin red siltstone (Jps) separates the ows. Thickness is 215-300 m (705-984 ft) or more Feltville Formation of the Brunswick Group in New Jersey and upper part of the Brunswick Group in Pennsylvania (Lower Jurassic)—Red, buff, gray, black, and white partly crossbedded, fine- to coarse-grained feldspathic sandstone; gray and black siltstone in fining-upward cycles; and a laterally continuous, gray, laminated limestone. Lower half contains a unit of black to white laminated limestone, calcarenite, graded siltstone, and crossbedded siltstone and sandstone about $1-10\ m$ (3-39 ft) thick. Fossiliferous, with reptiles, arthropods, abundant fish, and diagnostic spores and pollen. About 170-600 m

the flows contain vesicles near the top. As much as 110 m (361 ft) thick

Orange Mountain Basalt of the Brunswick Group in New Jersey and Jacksonwald Basalt of the Brunswick Group in Pennsylvania (Lower Jurassic)—The Orange Mountain Basalt comprises at least two tholeitic, pillowed pahoehoe, and columnar basa lows, with thin interbedded volcaniclastic rocks that are about 1-4 m (3-13 ft) thick, in the called the Jacksonwald Basalt Member of the Brunswick Formation by MacLachlan, 1983). 9 km (5.6 mi) east of Reading, Penn., and another flow 8 km (5 mi) south of Flemington J., may be the same extrusive unit. Probably between 100 and 200 m (328 and 656 JRD JRbl Passaic Formation of Olsen (1980a) of the Brunswick Group in New Jersey and lower part of the Brunswick Group in Pennsylvania (Lower Jurassic and Upper Triassic)— Predominantly grayish-red to reddish-brown, evenly to irregularly bedded, thin- to thickpedded shale, siltstone, very fine to coarse-grained sandstone, and red-matrix nerate. Generally becomes coarser in the northeastern half of the basin in New Jersey. Mudcracks, ripple marks, crossbeds, and burrows are common, Contains detrital cycles of medium- to dark-gray and olive- to greenish-gray, thin-bedded and

evenly bedded shale and siltstone (Rpg, Rblg), similar to the rocks in the underlying Lockatong Formation (RI). Many cycles are known near New Brunswick and northeast of Lambertville, N. J., but are not shown on the map (Olsen, unpub. data, 1983). Greenish and brownish, fine- to coarse-grained, arkosic sandstone grades in places to quartzite fanglomerate (Rcq), and contains some interbedded red beds and impure limestone or alcareous shale. Locally contains dinosaur footprints. Individual cycles as much as 76 m (250 ft) thick: some cucles are too thin to show on this map. Lower contact with the ockatong Formation (RI) gradational through about 500 m (1,640 ft) and is mapped where thickness of red beds is dominant over thickness of grav and black beds. Interfinger laterally with the Lockatong (RI) and Hammer Creek (Rh) Formations. Where the unit grades laterally into the Lockatong, lower contact is either conformable and gradational to older rocks of the Newark Supergroup, or is unconformable on basement rocks. Contains reptiles, arthropods, pelecypods, plant impressions, spores, and pollen. The Jurassic-Triassic boundary lies within the uppermost 100 m (328 ft). The maximum thickness may exceed 6,000 m (19,685 ft) in the western part of the basin and is about 670 m (8,760 ft) in the northeastern part

The Hammer Creek Formation (Upper Triassic)—Red, brown, and less abundant light-gray. very fine to coarse-grained and conglomeratic, thin- to thick-bedded sandstone, with some rossbedding, lensing, channeling, and ripple marks, and thin- to medium-bedded rec shale and siltstone with ripple marks and mudcracks. Contains beds with abundant red and gray, thick- to very thick bedded conglomeratic sandstone with clasts of quartz, quartzite, sandstone, limestone, and shale as much as 25 cm (10 in) long (\Re hc). The contact between the Hammer Creek Formation (\Re h) and the lower part of the Brunswick Group JRbI) is arbitrarily placed in the Schuylkill River area. Thickness of the entire Hammer ek Formation may be as much as 2,800 m (9,187 ft) ockatong Formation (Upper Triassic)-Predominantly laminated to thick-bedded, ay and black siltstone and shale; rich in fossils, including plants, reptiles, fish, and ostic spores and pollen. Unit composed of alternating detrital and chemical-lacustring iltstone and shale overlain by platy to massive, disrupted (mudcracked and burrowed dark-gray, calcareous siltstone, ripple-bedded siltstone, and fine-grained sandstone; more common in the lower Lockatong. Averages about 5.2 m (17.1 ft) in thickness. Chemical cucles: Lower part platu, medium-dark-gray to black, dolomitic siltstone and markstone with shrinkage cracks and lenses of puritic limestone, overlain by massive, gray or red, analcime nd carbonate-rich, disrupted siltstone. Average thickness about 3.2 m (10.5 ft). Lowe contact of Lockatong gradational, placed at base of lowest continuous black siltstone bec ontains interbedded, reddish-brown, sandy siltstone in units from about 3 to 82 m (10 to 270 ft) thick (RIr). Interfingers laterally with and gradationally into the underlying Stockton Formation (Rs) as well as up into the Passaic Formation (JRp) and lower part of the Brunswick Group (JTbl). Wedges out between the Stockton (Tks) and Hammer Creek (Th) Formations west of the Schuylkill River. Maximum thickness about 1,180 m

> Stockton Formation (Upper Triassic)—Light- to medium-gray and light-yellowish-gray to pale-reddish-brown, thin- to thick-bedded, fine- to coarse-grained sandstone, arkose nd arkosic conglomerate with pebbles of quartz, quartzite, feldspar, shale, limestone, and morphic rocks locally more than 8 cm (3 in) long; grayish-red to moderate-reddishprown, and light- to medium-gray siltstone and shale, bioturbated by roots and burrows: nd grayish-red to reddish-brown, thin- to thick-bedded, very fine to medium-grained, arkosic sandstone, generally fining upward with abrupt lateral lithic changes. These rocks contain channels, ripple marks, mudcracks, crossbeds, pinch-and-swell structures, and ninor burrows. Purplish siltstone near the middle and top. Well-bedded, gray and grayreen, fossiliferous siltstone present locally in upper Stockton. Locally contains red mestone breccia filling solution cavities in Ordovician-Cambrian limestones. Local graand buff, thick-bedded to crudely bedded, arkosic conglomerate and arkose wi ubangular to rounded pebbles of quartz, quartzite, limestone, and underlying basemen ocks as much as 8 cm (3 in) long in a red, arkosic sand to silty shale matrix (Rsc). Units ontaining conglomerate average about 100 m (320 ft) in thickness. Lower contact nconformable. The Hammer Creek (Th) is a partial lateral correlative and unconformab verlies this unit. Maximum thickness is 1,830 m (6,000 ft) in the center of the basin, ninning in all directions to less than 250 m (820 ft) near Hoboken, N.J. In Montgomery punty and eastern Chester County, Penn., the Stockton is divided into three members. Opper shale member (Rsu), red shale and siltstone with some fine-grained, arkosic andstone. 18-305 m (60-1,000 ft) thick. Middle arkosic member (Fism), fine- to nedium-grained, arkosic sandstone with red shale and siltstone. 518-1,280 m (1,700-1,200 ft) thick. Lower arkosic member (TsI), medium- to very coarse grained, arkosic sandstone and conglomerate, with fine-grained, arkosic sandstone and red shale and siltstone. 168-823 m (550-2,700 ft) thick Limestone conglomerate (Upper Triassic)-Subangular, medium- to dark-medium-

ay limestone and dolomite clasts as much as 1 m (3.3 ft) in diameter (derived from Cambrian limestones in the immediate area) and rare gneiss pebbles and cobbles in a matrix of red, partly arkosic sandstone and siltstone. Generally becomes finer grained Quartzite conglomerate (Upper Triassic)-Rounded pebbles, cobbles, and boulders, as much as 30 cm (1 ft) long, of white, light-gray, and reddish quartzite, and lesser calcareous sandstone in a matrix of red, partly arkosic siltstone and sandstone. Source from Siluriar cks to north. Generally becomes finer grained southward. About 305 m (1,000 ft) thick Unclassified conglomerate (Upper Triassic)—Conglomerate and conglomeration sandstone with rounded to angular quartzite, limestone, gneiss, and basalt clasts as much as 1 m (3.3 ft) long. As much as 305 m (1,000 ft) thick in places

VALLEY AND RIDGE PROVINCE The Valley and Ridge province can be divided into lithotectonic units, each comprising a group of formations with their own deformation and erosion characteristics. Incompetent rocks, such as the Marcellus Formation and the top of the Martinsburg Formation, are zones of detachment separating the lithotectonic packages. Alleghanian deformation, dominated by a thrust system of imbricate splays, has produced a series of northeast-trending, northwest-verging, upright to overturned folds. Many of the anticlines may be directly related to blind thrusts at depths. Figure 2 shows stratigraphic and facies relations of Silurian and Devonian rocks.

Pl Llewelyn Formation (Upper and Middle Pennsylvanian)—Very light gray to grayishblack, light-brownish-gray, greenish-gray, and grayish-orange, very thin to thick-bedded siltstone and shale with abundant plant debris; evenly bedded to lenticular, partly channeled, graded, crossbedded, and rippled, fine- to coarse-grained sandstone and onglomerate; evenly bedded to lenticular, partly channeled, graded, crossbedded, and ppled conglomeratic sandstone with quartz and quartzite pebbles; and less abundant thert and metamorphic rock fragments as much as three inches in diameter with numerous anthracite coal beds. Lower contact sharp and placed at base of shale or underclay beneath the Buck Mountain (No. 5) coal bed (not identified on the map). 275–625 m (900–2,050 Pottsville Formation (Middle and Lower Pennsylvanian)-Light- to dark-gray and olive gray to vellowish-brown, thin- to very thick bedded, planar-bedded and crossbedded

abular to lenticular conglomerate; fine- to coarse-grained sandstone with quartz and quartzite pebbles as much as 20 cm (8 in) long; minor pebbles of other metamorphic and nentary rocks; less abundant shale and siltstone with plant debris; and several bed of anthracite coal. Lower contact at top of highest red bed of underlying Mauch Chun formation (IPMm). 250-450 m (820-1,475 ft) thick PMm Mauch Chunk Formation (Lower Pennsylvanian and Upper Mississippian)—Grayishnd crossbedded, partly lenticular and channeled, very fine to medium-grained sandstone some shale and siltstone, and minor conglomerate with quartz and quartzite pebbles more an 8 cm (3 in) long. Mudcracks, ripple marks, and raindrop impressions are common ower contact is gradational and placed at base of lowest red bed above gray beds of the inderlying Pocono Formation (Mp). About 950 m (3,100 ft) thick

> Pocono Formation (Lower Mississippian)-Light- to medium-gray, thin- to very thick edded, quartzitic conglomerate with quartz pebbles and minor amounts of chert and quartzite pebbles as much as 8 cm (3 in) long; structureless and crossbedded, medium-grained sandstone; and minor thin, lenticular beds of light- to dark-gray siltstone and shale a abundant plant debris. Lower contact sharp and unconformable. 225–305 m (820 Spechty Kopf Formation (Lower Mississippian and Upper Devonian)—Light-oliveray to grayish red-purple, discontinuous, generally massive and unsorted, polymictic ite; quartzite, schist, slate, gneiss, quartz, and siltstone pebbles generally as nuch as 10 cm (4 in) in diameter; some larger clasts. Locally grades up into partly aminated, light-olive-gray, shaly and pebbly siltstone and shale; white, planar-bedded rippled, very thin to thin-bedded, well-sorted sandstone with some load casts; an medium-gray, poorly bedded, fine- to coarse-grained, conglomeratic sandstone with

rmation, 115-275 m (375-900 ft) thick

conformity with basal diamictite resting on red or gray rocks of the underlying Catskill

Catskill Formation (Upper Devonian) Duncannon Member—Grayish-red and medium-gray, fine- to very coarse grained, partly massive and crossbedded, very thick sandstone beds with scoured bases; fissile to massive very thick bedded siltstone and shale with burrows and roots; and minor, massive, partly edded conglomerate with red and white quartz and quartzite pebbles and cobble as much as 15 cm (6 in) long, in fining-upward cycles. Thick, red, basal conglomerate rests on greenish-gray siltstone of underlying Clarks Ferry Member (Dccf). 152-296 m (500-970 Poplar Gap Member—Poplar Gap Member of Berg (1975) is here adopted for use by the eological Survey. Medium-gray, light-olive-gray to greenish-gray, fine-to very coarse grained, very thin to very thick bedded, planar-bedded and crossbedded sandstone and onglomeratic sandstone with quartz pebbles as much as 2.5 cm (1 in) long; pale- to grayish ed, medium- to thick-bedded shale, siltstone, and sandstone with burrows and pla ragments; and some discontinuous, dark-gray siltstone beds as much as 0.6 m (2 ft) thick. Base at bottom of lowest red bed above conglomerate of the Packerton Member (Dcp). Grades southwestward into the Clarks Ferry Member (Dccf) and Berry Run and Sawmill n Members (Dcbs). 259-518 m (850-1,700 ft) thick Clarks Ferry Member—Greenish-gray, olive-gray, bluish-gray, brownish-gray, and grayish-red, fine- to very coarse grained, thin- to very thick bedded, rippled, planar-bedded

crossbedded sandstone and minor conglomerate with pebbles of quartz, sandstone and argillite; and minor greenish-gray and olive-gray, flaggy siltstone. Basal conglomerate n abrupt contact on red siltstone and fine-grained sandstone of underlying Berry Run Member (Dcbs), 122–276 m (400–904 ft) thick Berry Run and Sawmill Run Members, undivided Berry Run Member-Light- to medium-gray, yellowish- to olive-gray, greenish-gray, brownish-gray, and grayish-red, very fine to very coarse grained, laminated to ver thick bedded, planar-bedded, crossbedded, partly conglomeratic (granule) and calcareous sandstone; medium-light- to greenish-gray, dark-bluish-gray and grayished, laminated and flaggy siltstone; and minor greenish-gray and dark-reddish-brown shale; partly in fining-upward cycles. Basal sandstones form topographic high next t valleys underlain by gray and red siltstone of Sawmill Run Member. 300-335 m (980-

Sawmill Run Member—Greenish-gray, olive-gray, brownish-gray, medium-gray, and

grayish-red, very fine to medium-grained, laminated to very thick bedded, crossbedded, planar-bedded, and irregularly bedded, partly calcareous sandstone with some plant fossils; pale- to dusky-red, olive-gray, brownish-gray, and greenish gray, laminated to thin-bedded shale. Basal contact placed at bottom of red siltstone verlying gray sandstone of Packerton Member (Dcp). Forms valleys. 43-130 m Packerton Member-Medium-gray, olive-gray, greenish-gray, brownish-gray, and minor calcareous, thin- to very thick bedded sandstone with some plant debris and fossil fish agments; minor conglomerate with quartz, sandstone, and siltstone pebbles as much as cm (1 in) long and shale clasts as much as 15 cm (6 in) long; and lenses of olive-gray shale. Lower contact at base of gray sandstone, or locally, at base of gravish-red onglomeratic sandstone overlying red shale of Long Run Member Long Run Member-Grayish-red to grayish-red-purple and minor greenish-gray nated to thick-bedded siltstone and shale with minor ripple marks, burrow mudcracks, roots, and dark-vellowish-orange, ferroan dolomite nodules; and medium-to medium-dark-gray, greenish- to olive-gray, and grayish-red, laminated to thick-bedded, planar-bedded and minor crossbedded, silty, limonitic, and micaceous sandstone with some channeled bases with rare quartz-pebble conglomerate, load casts, ripple marks hale chips, bivalves, crinoid columnals, and plant fragments. Many fining-upward cycles

ase placed at bottom of lowest red bed above gray rocks of Beaverdam Run Member Ocbr), 634 to about 1,000 m (2,080–3,280 ft) thick Beaverdam Run Member-Light- to medium-dark-gray, light-olive- to greenish-gray, and oderate-brownish-gray, laminated to thick-bedded, planar-bedded and crossbedded very fine to fine-grained, limonitic, micaceous, partly silty sandstone; a few thin, granule onglomerate zones; some load casts, ripples, channeled bases of sandstones, burrows, nd shale chips; and generally thin-bedded siltstone and shale. Several beds are ossiliferous with Tentaculites, crinoid columnals, brachiopods, pelecupods, and plant ments. Base placed at top of uppermost red bed of underlying Walcksville Member Dcw). 61-351 m (200-1,150 ft) thick; thins southward and eastward by intertonguing with the underlying Walcksville Member Walcksville Member-Grayish-red to medium-brownish-gray, and olive- to greenish-gray,

laminated and ripple-laminated to massive, bioturbated, partly mudcracked siltstone and silty shale with irregular ferroan dolomite nodules and some rootlets; and medium-to moderate-greenish-gray, grayish-red-purple, very fine to medium-grained, planar-bedded and crossbedded, thin- to thick-bedded, limonitic sandstone; and a few thin, shale-chip conglomerates. Beds are mostly in fining-upward cycles. Lower contact placed at base of ed bed above non-red rocks of the Towamensing Member (Dct). 76–762 m (250-500 ft) thick: thickens eastward and southward nensing Member—Medium-light- to medium-dark-gray, and olive- to greenish-gray very fine to medium-grained, thin- to thick-bedded, generally flaggy, planar-bedded and less abundantly crossbedded and rippled, partly graded, limonitic sandstone with some load casts; and lesser light-olive- to medium-greenish-gray and dark-gray, laminated to thin-bedded and ripple-bedded siltstone and silty shale. Locally contains brachiopods, rinoid columnals, pelecypods, Tentaculites, and plant fragments. Lower contact place at base of lowest sandstone above predominantly blocky siltstone of the Trimmers Rock Formation (Dtr). 58–183 m (190–600 ft) thick

Walcksville and Towamensing Members, undivided—Shown in cross section only. ludes units Dcw and Dct Poplar Gap and Packerton Members, undivided—Shown in cross section only. Includes Clarks Ferry, Berry Run, Sawmill Run, and Packerton Members, undivided-Shown in Trimmers Rock Formation (Upper Devonian)—Medium- to medium-dark-gray, and are olive-gray, laminated to thin-bedded, planar-bedded and cross-laminated, siliceous, blocky, graded siltstone to fine-grained sandstone and silty shale with some burrows, load casts, groove casts, scour-and-fill structure, ball-and-pillow structure, wavy laminations, laser bedding, brachiopod, crinoid, bryozoan fossil debris, and plant fragments. Lowe contact is transitional and placed at base of dominantly siliceous siltstones which are botton of ridge-forming sequence. 183–396 m (600–1,300 ft) thick

Mahantango Formation (Middle Devonian)—Medium-dark- to dark-gray, poorly bedded and laminated to thin bedded, bioturbated, shaly siltstone and silty shale. Fossil are diverse and scarce to abundant in different parts of the formation. Many fossiliferous intervals, at least four of which have been traced for many kilometers; mappable biostromes made up of abundantly fossiliferous (brachiopods, pelecypods, crinoids bryozoans, corals, trilobites, gastropods, and others), slightly calcareous and noncalcareous, medium-light- to dark-gray, silty shale and shaly siltstone. These biostromes range from about 3 to 20 m (10 to 65 ft) thick. Near the top of the formation is the Nis Hollow Siltstone Member, a medium-light- to medium-dark-gray and olive-gray laminated to thin-bedded, siliceous, slightly fossiliferous, blocky siltstone to very fine (56 ft) thick, but cannot be identified west of the New Ringgold 7.5-minute guadrand Near the base of the Mahantango in the New Ringgold quadrangle is a poorly exposed very fine grained graywacke that may be the easternmost feathered edge of the Montebell andstone Member. The lower contact of the Mahantango is gradational through 30 to 0 m (100 to 200 ft) of siltstone and shale. Thickness is 360-785 m (1,180-2,575 ft Marcellus Shale (Middle Devonian)—Medium-dark-gray to grayish-black, laminated to poorly bedded, sparingly fossiliferous (depauperate brachiopod fauna) shale and silty shale. Lower part, as much as 60 m (200 ft) thick in the east and less than 21 m (70 ft)

calcareous, shaly siltstone and argillaceous limestone (Stony Hollow Member) above, an edium-dark-gray to grayish-black shale (Union Springs Member) below. The Tioga As Bed, a pyritic, micaceous, tuffaceous shale occurring in three thin beds, is exposed at and 9 m (28 ft) of the base in the Lehighton quadrangle Buttermilk Falls Limestone through Esopus Formation, undivided—Ranges from 81 o 168 m (265 to 550 ft) thick. See figure 2 for stratigraphic relations and thicknesses of Buttermilk Falls Limestone (Middle Devonian)—Medium- to medium-dark-ora very thin to thin-bedded, irregularly bedded, fossiliferous, fine- to very coarse grained cherty limestone and argillaceous limestone with abundant crinoid columnals as much as $2.5\,$ cm $(1\,$ in) in diameter in lower part; deeply leached in western exposures. Contains Tioga Ash Bed, about $7.6\,$ m $(25\,$ ft) below top and $34\,$ cm $(1.1\,$ ft) thick near Palmerton Sandstone (Middle and Lower Devonian)-Very light to medium-darkgray, medium- to very coarse grained, generally massive sandstone and conglomeratic sandstone with quartz pebbles as much as 2 cm (0.75 in) long Schoharie Formation (Middle and Lower Devonian)—Medium-gray to grayish-black aminated to very thick bedded, slightly cherty, fossiliferous, calcareous siltstone with aonurus and other burrows

thick in the west consists of medium-to medium-dark-gray, laminated to thin-bedded

Esopus Formation (Lower Devonian)—Medium- to dark-gray, well-cleaved, generally laminated to poorly bedded siltstone with abundant Taonuru Schoharie and Esopus Formations, undivided (Middle and Lower Devonian)fostly weathered, medium-light- to dark-gray, laminated to thin-bedded, block partly cherty, siliceous siltstone to fine-grained sandstone with Taonurus. Lower contact with Ridgeley Sandstone (Doh) is unconformable Oriskany Group through Helderberg Group, undivided (Lower Devonian)-Ranges om 55 to 125 m (180 to 410 ft) in thickness. Lower contact with Rondout and Decke ormations (Sdp) gradational. See figure 2 for stratigraphic relations and thicknesses of Ridgeley Sandstone of the Oriskany Group-Light- to medium-gray, fine- to very coarse grained, evenly to unevenly bedded, thin-bedded, fossiliferous (spirifer brachiopods), calcareous sandstone and conglomerate with quartz pebbles as much as 2 cm (0.75 in) long, with minor siltstone, arenaceous limestone, and chert Shriver Chert of the Oriskany Group—Medium-dark-gray, calcareous, fossiliferous Port Ewen Shale of the Helderberg Group-Medium-dark-gray, fossiliferous irregularly bedded to laminated, burrowed, well-cleaved, calcareous shale and Minisink Limestone of the Helderberg Group-Medium- to dark-gray, argillaceous fine-grained, fossiliferous limestone and calcareous shale New Scotland Formation of the Helderberg Group-Medium-dark- to dark-gray. well-cleaved, cherty, fossiliferous, calcareous and silty shale and argillaceou Coeymans Formation of the Helderberg Group—Medium- to dark-gray, fine- to very coarse grained, irregularly bedded, very fine to thick-bedded, argillaceous and arenaceous, partly cherty, fossiliferous, burrowed, partly biohermal limestone, and

nedium-gray, fine- to coarse-grained and pebbly, fossiliferous, crossbedded and planar-bedded, calcareous sandstone and conglomerate with quartz pebbles as much as $2.5 \, \text{cm} \, (1 \, \text{in}) \, \text{long}$ Dbe and Doh combined. Shown in cross section only Buttermilk Falls Limestone through Coeymans Formation, undivided (Middle and Lower Devonian)—Generally similar to Dbe and Doh to east except that units are generally deeply weathered and thinner. Limestone content of the Coeymans Formation decreases westward. Therefore this unit may not extend west of the Lehighton 7.5-minute quadrangle, but could be represented by rocks of the Andreas Red Beds of Swartz and uartz (1941) Definitive discrimination of the New Scotland Formation, Oriskany Grou Schoharie and Esopus Formations, and Palmerton Sandstone west of the Lehighton 7 minute quadrangle has not been described. Unit ranges from about 15 to 136 m (50 to 445 ft) in thickness. See figure 2 for stratigraphic relations and thicknesses of individual unit Rondout Formation and Decker Formation through Poxono Island Formation, undivided (Upper Silurian)—About 53 to 280 m (175 to 920 ft) thick. Lower conta gradational and placed at top of predominantly red sequence of underlying Bloomsburg Red Beds (Sb). See figure 2 for stratigraphic relations and thicknesses of individual units Rendout Formation—Light- to medium-dark-gray, very fine to medium-grained fossiliferous, laminated to thin-bedded limestone; mudcracked, calcareous shale; and medium- to dark-gray, very fine grained, laminated, mudcracked dolomite Decker Formation-Medium-light- to medium-dark-gray, calcareous, fine- to coarsegrained, thin-bedded, crossbedded to planar-bedded to flaser-bedded, fossiliferous irrowed sandstone: calcareous conglomerate with quartz pebbles as much as 1.3 cm (0.5 in) in diameter; calcareous siltstone; fine- to coarse-grained, arenaceous secomes more conglomeratic to the southwest

greenish-gray, very fine to very coarse grained and conglomeratic, thin- to thick (1 in) in diameter; and burrowed shale and siltstone. May correlate with either the peymans Formation or upper part of the Decker Formation Bossardville Limestone-Medium- to dark-gray and olive-gray, very fine to fine grained, laminated to thin-bedded, wavy-bedded, graded, fossiliferous (mainly perditiid ostracodes), argillaceous, and partly dolomitic limestone; and olive-gray calcareous shale with mudcrack polygons more than 5 m (15 ft) deep and some olomite intraclasts as much as 2.5 cm (1 in) in diameter Poxono Island Formation—Pale-green to greenish-gray, and medium- to dark-gray partly mudcracked, ostracode-bearing, laminated to thick-bedded, calcareous shall very fine to fine-grained dolomite; and argillaceous limestone with dessication breccial locally at the top and pale-red, interbedded shale near the bottom Buttermilk Falls Limestone through Poxono Island Formations, undivided (Middle onian through Upper Silurian)—Shown in cross section only. Includes units Dbh and Srp. Applies only to central part of Valley and Ridge province on map. See figure 2 for Buttermilk Falls Limestone through Poxono Island Formation, undivided (Middle Devonian through Upper Silurian)—Rocks of the Ridgeley Sandstone of the Orskany Group, Andreas Red Beds of Swartz and Swartz (1941), Decker Formation, Bossardville Limestone, Poxono Island Formation, and possibly the New Scotland Formation are recognized in scattered outcrops. The Buttermilk Falls Limestone is probably present under cover. Continuation of the Palmerton Sandstone, Esopus Formation, and Schoharie Formation from the northeast into the westernmost part of the Newark 1° x 2° quadrangle is uncertain. Thickness about 53–69 m (175–225 ft). See figure 2 for stratigraphic relations thicknesses of individual units Bloomsburg Red Beds (Upper Silurian)—Grayish-red to dark-reddish-brown, pale-red

Andreas Red Beds of Swartz and Swartz (1941)—Pale- to gravish-red and light-

grayish-red-purple, and greenish-gray to pale-green, crossbedded and planar-bedded laminated to thick-bedded shale, siltstone, very fine to coarse-grained sandstone, and minor conglomeratic sandstone with cut-and-fill structures, mudcracks, ferroan dolomite nodules, local fish scales, and red mudstone intraclasts as much as 8 cm (3 in) long. Many fining-upward cycles. Lower contact gradational, very irregular in places, and placed at base of lowest red bed above gray rocks of the Shawangunk or Clinton Formation. 244 Shawangunk Formation (Silurian and Upper Ordovician (?))—Three members of the hawangunk Formation extend southwestward into the Slatedale 7.5-minute quadrangle. on the southwest of the quadrangle, only the Lizard Creek and the Minsi Members maintain neir identity. These two members are similar to the Clinton Formation and Tuscarora Sandstone. The arbitrary boundary between the Shawangunk and the Clinton-Tuscarora is therefore placed in the Slatedale 7.5-minute quadrangle Tammany Member (Middle Silurian)—Medium- to medium-dark-gray, planar-bedded and crossbedded, thin- to thick-bedded, fine- to coarse-grained and conglomerati quartzite with quartz and argillite pebbles as much as 5 cm (2 in) long, and minor beds of dark-gray argillite. Lower contact gradational. 0–249 m (0–816 ft) thick. Grades laterally to the southwest into the Lizard Creek Member (SsI) in the Kunkletown 7.5-minute Lizard Creek Member (Middle Silurian)-Light- to dark-gray and light-olive- to dark greenish-gray, very fine to coarse-grained, laminated to very thick bedded, planar-bedded, crossbedded, flaser-bedded, rippled, partly channeled, burrowed quartzite with flattened argillite cobbles as much as 10 cm (4 in) in diameter; minor dark-grayish-red-purple, fine grained, burrowed, hematitic quartzite, interbedded with medium-light- to dark-gray and olive- to greenish-gray, laminated to thin-bedded, flaser-bedded, burrowed siltstone and shale; scattered thin beds contain collophane, siderite, and chlorite nodules, quartz pebbles as much as 0.6 cm (0.25 in) long, and Lingula and eurypterid fragments. Lower contact

above quartzites of underlying member. 82-427 m (270-1,400 ft) thick; thins southwestward and is replaced by the Clinton Formation (Sc) southwest of the Slatedal .5-minute quadrangle Minsi and Weiders Members, undivided (Lower Silurian and Upper Ordovician) Minsi Member-Very light to dark-gray and light-olive- to greenish-gray, partly burrowed, planar-bedded and crossbedded, thin- to thick-bedded, fine- to coarse rained, partly conglomeratic quartzite with pebbles of quartz and chert not more than 5 cm (2 in) in diameter and cobbles of shale as much as 18 cm (7 in) in diameter minor medium-dark- to dark-gray and greenish-gray, laminated to thin-bedde ocally mudcracked siltstone and shale. Local Arthrophycus. Lower contact placed a op of uppermost bed of the Weiders Member containing quartz pebbles more that 5 cm (2 in) long or, northeast of the Kunkletown 7.5-minute quadrangle, in share ermable contact with the Martinsburg Formation. 61-107 m (200-350 fi hick. These two units are not recognized southwest of the Slatedale 7.5-minut guadrangle and the combined unit in that area is called Tuscarora Sandstone (SOt) Weiders Member-Medium-light- to medium-dark-gray and greenish-gray, planar bedded and crossbedded, thin- to thick-bedded, medium- to very coarse graine artzite; conglomerate with quartz and chert cobbles as much as 17 cm (6.5 in) in diameter and shale cobbles as much as 20 cm (8 in) in diameter; and rare, greenish gray, laminated to thin-bedded argillite. Lower contact with Martinsburg Formatio ormable. 0-67 m (0-220 ft) thick. Pinches out southwest of Slatedale 7 minute quadrangle (where it is equivalent to part of the Tuscarora Sandstone) and northeast of the Kunkletown 7.5-minute quadrangle

transitional and placed at base of lowest argillite in sequence containing abundant argillite

ammany through Weiders Members, undivided (Silurian and Ordovician)—Shown in ross section only. Includes units Sst, Ssl, and SOsw Clinton Formation (Middle Silurian)—Gray, green, and red sandstone, siltstone and hale laterally continuous with and lithically similar to the Lizard Creek Member of the Shawangunk Formation (SsI), except that it contains more red beds. Lower contact gradational. About 396–427 m (1,300–1,400 ft) thick uscarora Sandstone (Lower Silurian and Upper Ordovician)—Gray quartzite laterally continuous with and similar to the Minsi Member of the Shawangunk Formation, Lower contact abrupt and unconformable. About 76 m (250 ft) thick GREEN POND SYNCLINE

The Green Pond syncline is a narrow, northeast-trending, faulted syncline containing a thin, but fairly emplete section of Paleozoic sediments, located in the middle of the external massif of the Reading frong. The very narrow southwestern end of this structure is located in the Newark 1° x 2° quadrangle he Paleozoic rocks sit unconformably upon the Proterozoic basement. However, the Paleozoic section is cut by a number of thrust faults, and in places the contact between the basement and cover rocks may be structural. In places, folds in the Paleozoic section are decoupled from the older basement rocks. Many of the Paleozoic rocks correlate with thicker units in the Valley and Ridge Province (see the Correlation of Man Units) showing that these rocks once were present between the two areas, a distance of more han 25 kilometers. A significant strike-slip component of movement is possible on the normal faults in

Bellvale Sandstone (Middle Devonian)-Bellvale Flags of Darton (1894) is herein adopted for use by the U.S. Geological Survey as Bellvale Sandstone. Medium-gray, flaggy sandstone, black shale and siltstone, sandier in upper part. Grades upward into red sandstone, shale, and conglomerate of the Skunnemunk Conglomerate, which is exposed just north of the Newark 1° x 2° quadrangle. About 610 m (2,000 ft) thick Marcellus Shale (Middle Devonian)—Very dark gray, sparsely fossiliferous shale y in upper part. About 180 m (590 ft) thick onnelly Conglomerate, Esopus Formation, and Kanouse Sandstone, undivided ower Devonian)—Total unit thickness about 117 m (383 ft) Connelly Conglomerate -- Connelly Conglomerate of Chadwick (1908) is herei adopted for use by the U.S. Geological Survey. White to light-gray, fossiliferous conglomerate and quartz-pebble conglomerate. Lower contact unconformable

Esopus Formation-Light- to dark-gray, fossiliferous (Taonurus) siltstone and finegrained sandstone; dark-gray to black mudstone and siltstone. Lower contact unconformable. About 90 m (295 ft) thick Kanouse Sandstone-Light-gray, thick-bedded, fine conglomerate with quartz pebbles as much as 10~mm (0.4 in) long; sandstone in lower part grades upward into sparsely fossiliferous sandstone. About 15~m (49 ft) thick Decker and Poxono Island Formations, undivided (Upper Silurian)-Total unit ickness about 144 m (473 ft Decker Formation-Very thin to thin-bedded, fossiliferous, gray to greenish-gray, calcareous siltstone and medium-gray dolomite, with interbedded olive-gray shale. al sandstone and conglomerate beds near base. Lower contact conformable. About 38 m (125 ft) thick

Poxono Island Formation-Medium-gray, greenish-gray, grayish-yellow-weatherin laminated to thin-bedded, mudcracked, and burrowed dolomite, interbedded with greenish-yellow, medium-grained, thin- to thick-bedded, crossbedded sandstone; nd green, purple, and bluish-gray, laminated to very thin bedded, silty shale and green siltstone. Lower contact gradational. About 106 m (348 ft) thick High Falls Formation (Upper Silurian)—Grayish-red, nonfossiliferous, silty shale with andstone common in lower half. Lower contact probably transitional. About 91–107 Green Pond Conglomerate (Upper Silurian)—Gray and reddish-gray sandstone and onglomerate with predominantly white quartz and minor gray, green, red, and yellow chert, red shale, and red sandstone cobbles as much as 7.6 cm (3 in) long. Lower contact unconformable. About 300-425 m (984-1,394 ft) thick

LEHIGH VALLEY AND SCHUYLKILL SEQUENCES The Great Valley of Pennsylvania and New Jersey is a northeast-trending lowland bounded by Blue Mountain-Kittatinny Mountain on the northwest and the highlands of the Reading Prong on the southeast. The Lehigh Valley sequence, within the Great Valley, comprises a thick section of Ordovician clastics, a thinner section of Ordovician and Cambrian carbonates, and a very thin Cambrian quartzite at its base. All of these rocks have been multiply deformed, perhaps by a continuum of deformation between Taconic nd Alleghanian time. These rocks contain a large number of thrust faults concentrated at several stratigraphic levels. These include: 1) the entire lower thin-bedded slate member of the Martinsburg Formation (Omb), 2) the incompetent Jacksonburg Limestone (Oj) which sits stratigraphically on top of the much more competent, dolomite-dominated Beekmantown Group, and 3) the base of the Allentown Dolomite (OCa) or Leithsville Formation (CI). The lowest unit in both sequences, the Hardyston Quartzite (CI), almost always decoupled from the rest of the cover rocks during thrusting and acted as a thin veneer welded on top of the thrust slices of Proterozoic basement. In the Topton quadrangle, the rocks of the Lehigh Valley sequence are structurally overlain by the Schuylkill sequence. The Schuylkill sequence differs from the Lehigh Valley sequence in Pennsylvania by: 1) the absence of the cement limestone facies of the Jacksonburg Limestone (Oj), 2) having a thick, continuous belt of Ontelaunee Formation (Oo), 3) the presence of the Stonehenge Formation (Os), and 4) the presence f mappable members in the Allentown Dolomite (O€a). Since the Jacksonburg Limestone (Oj) and the Allentown Dolomite (O€a) are not subdivided on this map, the Lehigh Valley and Schuylkill sequences are not separated on the correlation chart. The rocks of the Schuukill sequence are in turn ructurally overlain by the rocks of the Lebanon Valley sequence in the Birdsboro quadrangle. The rocks of the Lebanon Valley sequence appear, at least in part, to be slightly deeper water, and perhaps farther

travelled, equivalents of the Lehigh Valley and Schuylkill sequences. Pen Argyl Member (Upper Ordovician)—Dark-gray to grayish-black, thin- to thick-bedded, evenly bedded slate, commonly more than 3 m (12 ft) and in places 6 m (20 ft) thick: rhuthmically interlayered with carbonaceous slate, sandy slate, and very fine to medium-grained graywacke with parallel lamination, lenticular bedding, convolute bedding, and sole marks. Units in fining-upward sequences (turbidite-flysch). Quarried extensively for slate ("soft slate" of Pennsylvania quarrymen). Upper contact is unconformable and site of a regional decollement. Lower contact is gradational and is placed where graywacke is in excess of about 5 percent of local sequences and supplies abundant float. Though present in eastern Pennsylvania, the Pen Argyl is overlapped by he Shawangunk Formation (Sst, Ssl, SOswm) just west of the Delaw bsent in northern New Jersey. Thickness ranges from 1,000–2,100 m (3,280–6,900 ft) Ramseyburg Member (Upper and Middle Ordovician)—Medium- to dark-gray slate that alternates in part cyclically, with light-to medium-gray, thin- to very thick bedded graywacke and graywacke siltstone (turbidites). Graywacke comprises about 20 percent of member, but may make up more than 50 percent of some thick parts of the section and less than 5 percent in others. Slates are generally thick bedded at the top and thin to medium bedded at the bottom of the member. Lower contact is placed at the base of lowest conspicuous graywacke bed, generally recognized by abundant float, but contact may be transitional through several hundred feet, where discontinuous and lenticular graywacke beds are present in the underlying Bushkill Member (Omb). Thickness ranges om 850–930 m (2.800–3.050 ft) Bushkill Member (Middle Ordovician)—Medium- to dark-gray, laminated to thin-bedded slate containing thin beds of quartzose slate, graywacke siltstone, and carbonaceous slate

in fining-upward sequences. Bed thickness does not exceed 15 cm (6 in) throughout nember, and is generally less than 5 cm (2 in), except for graywacke beds that probable are less than 30 cm (12 in) thick in discontinuous units near the top of the member. Lower contact transitional through 1 m (3 ft). Formerly quarried for slate ("hard slate" belt of ennsylvania quarrymen). Minimum thickness is about 1,525 m (5,000 ft Jacksonburg Limestone (Middle Ordovician)—The upper part, referred to as the "cement rock" facies, is a dark-gray to almost black, fine-grained, thin-bedded, argillaceous limestone. Contains beds of crystalline limestone in places. Upper contact gradational. ower contact gradational in eastern Pennsylvania and main outcrop belt of northern New Jersey, but is unconformable and marked by a conglomerate in the Paulins Kill lowlands of New Jersey. Thickness ranges from 100–300 m (330–1080 ft). The lower unit, referred to as the "cement limestone" facies, is a light- to medium-gray, medium- to coarse-graine largely well bedded calcarenite and fine- to medium-grained, high-calcium limestone. At the western edge of the map, the lower contact is sharp but conformable, but becomes unconformable approaching the Delaware River. Continuing northeastward through New lersey, the lower contact is marked by beds of dolomite pebble- to boulder-conglomerat and the magnitude of this hiatus becomes greater with this unit progressively resting on older units in the Beekmantown Group. Thickness ranges from 20–130 m (65–430 ft) Ontelaunee Formation of the Beekmantown Group (Middle and Lower Ordovician)cherty at the base, grading into medium- to thick-bedded, medium-gray, fine- to mediumnit only sporadically present east of Northampton, Penn., and generally absent in New Jersey except as cobbles in the overlying conglomerates of the Jacksonburg Limestone (Oj). Lower contact is gradational. Thickness ranges from 0–200 m (0–650 ft) dark-medium-gray dolomite. Upper part of unit is absent in much of New Jersey. Low contact is gradational. Present in places as cobbles in the overlying Jacksonburg Limestone

Epler Formation of the Beekmantown Group (Lower Ordovician)—Very fine grained o cryptogranular, light- to medium-gray limestone and fine- to medium-grained, light- to conglomerates where the Ontelaunee Formation (Oo) is absent. Thickness is about Rickenbach Dolomite of the Beekmantown Group (Lower Ordovician)-Fine- to coarse-grained, light-medium- to medium-dark-gray dololutite, dolarenite, and dolorudite. Upper part generally thin-bedded and laminated; lower part characteristically thick-bedded. Lower contact gradational. In some places in New Jersey, this unit is present as cobbles in the overlying conglomerates of the Jacksonburg Limestone (Oi) where both the itelaunee (Oo) and Epler (Oe) Formations are absent. Thickness is about 220 m (720 onehenge Limestone of the Beekmantown Group (Lower Ordovician)-Mediumht- to medium-gray, fine-grained, thin-bedded limestone marked by silty or sandy laminae with subordinate beds of orange- to buff-weathering, irregularly laminated an mottled dolomite. The silty laminae are the residue left after extensive non-seam-suture

pressure solution. Dolomitic beds, generally near the base of the unit, are sparse in the western part of the map area, but increase in abundance eastward through Pennsylvania. In Pennsylvania, this unit is found in the Schuylkill sequence, but not in the Lehigh Valley sequence. In New Jersey, it reappears, and the amount of thin- to medium-bedded dolomite may equal the amount of thin-bedded limestone. Throughout the map area, the resence of chert is rare. In some areas, particularly just east and west of the Delaware River, the formation has not been recognized. In the same region, the Rickenbach Dolomite Or) increases in thickness, and it is possible that dolomite of Stonehenge age occurs there. so, it is difficult, if not impossible, to distinguish from the Rickenbach without the presence of fossils. Therefore, for the purposes of this map, the Stonehenge is considered to be missing from the central portion of the map area. Thickness ranges from 0–100 m (0–32) Allentown Dolomite (Lower Ordovician and Upper Cambrian)-Very fine to mediumgrained, light- to medium-dark-gray, alternating light- and dark-gray-weathering, rhuthmically bedded dolomite: contains abundant flat-pebble conglomerate, calcilutit calcarenite, oolitic calcarenite, calcirudite, algal stromatolite, dolomicrite, and scattered

boundary is within this unit, very close to the upper contact. Thickness is about 575 m eithsville Formation (Middle and Lower Cambrian)—Interbedded, light-medium-gray ne- to coarse-grained dolomite and calcitic dolomite, light-gray to tan phyllite, and ve thin beds and stringers of quartz and dolomitic sandstone. Lower contact is gradational where present, but is commonly marked by numerous thrust faults making thickness estimates difficult. However, where the lower contact is gradational, the unit is approximately 330 m (1,000 ft) thick Hardyston Quartzite (Lower Cambrian)—Fine- to medium-grained, white to dark-grav. light-buff-and reddish-gray-weathering, fine- to medium-grained, thin- to medium-bedd mmonly massive, but in some places thinly laminated and crossbedded, Scolith bearing, feldspathic quartzite interbedded with arkose, quartz-pebble conglomerate, and silty shale or phyllite. Lower part commonly consists of quartz-pebble conglomerate with a matrix of coarse, feldspathic sandstone and minor dark-gray argillite. generally unconformable and abrupt. Thickness ranges from 0 to 30 m (100 ft) in New ersey, but thickens both southwestward toward the Schuylkill River to 20-40 m (70-125 and southward to the Buckingham Valley where it reaches 270 m (900 ft) SPITZENBERG AND SHARPS MOUNTAIN OUTLIERS These two small erosional remnants in the Great Valley north of Hamburg, Penn. contain reworked

nd perhaps with structural discontinuity, on rocks of the Hamburg klippe and unconformably benea e Tuscarora Sandstone (SOt). Although difficult to prove, these rocks may have been deposited after rocks of the Hamburg klippe were folded during the Taconic orogeny and may represent the youngest Ordovician clastics in the area Sandstones and conglomerates of Spitzenberg and Sharps Mountain (Late Ordovician)—At Spitzenberg, the unit consists of medium- to coarse-grained, medium-to thick-bedded, poorly to well-sorted, crossbedded, red- and green- weathering, onglomeratic sandstone, interbedded with a thick-bedded, polymict conglomerate. clasts include green chert, milky-white calcilutite and laminated to cross-laminated calcisiltite, red and maroon shale, brown sandstone and siltstone, and clasts of the same ndstone that is interbedded with the conglomerate. Conodon that the clasts are youngest at the bottom of the unit and oldest at the top. At Sharps Mountain, the sandstone is common, although it weathers differently (to a greenish-white) and the conglomerate is absent. These rocks are unconformable on, and possibly in thrus contact with, the underlying rocks of the Hamburg klippe. The underlying klippe rocks

ediments of both the Hamburg klippe and the Lehigh Valley sequence. These rocks rest unconformably,

are a partial source for this unit both at Sharps Mountain and Spitzenberg. At Sharps Mountain, the unit is unconformably overlain by the Tuscarora Sandstone (SOt). Thrusting may be localized at this contact. Thickness is 60 m (200 ft) ROCKS OF THE SHOCHARY RIDGE AREA This group of Ordovician clastic rocks crops out over a fairly small area in the Great Valley of eastern vania. It is entirely fault bounded, and sits structurally on top of all three members of the Martinsburg Formation (Omp. Omr. Omb), and lies structurally beneath the Windsor Township mation (Owd, Ows, Oww, Owc, Owr) of the Hamburg klippe. The eastern end of the Shocha Ridge outcrop belt coincides almost exactly with the eastern end of the Hamburg klippe. It is likely that the rocks of Shochary Ridge are derived from the Windsor Township Formation (Greenwich slice) of the Hamburg klippe and were transported in Taconic time as a thrust sheet beneath the two major slices of the klippe. The Eckville and Kistler Valley faults, bounding the Shochary Ridge area on the north and south, respectively, are probably Alleghanian in age. The rocks of the Shocharv Ridge area formed as a local, northward-prograding deltaic fan. The source of these clastics was the advancing accretional prism of the Greenwich slice of the Hamburg klippe. These rocks are roughly the same age as the slightly deeper water clastics of the Martinsburg Formation (Omp. Omr. Omb), which were deposited by longitudinal (dominantly northeast or southwest) currents within a very long northeast-trending basin

Shochary Sandstone (Upper and Middle Ordovician)-Medium-dark-grav. thin- to thick-bedded (5-75 cm, 2-30 in) calcareous, pyrite-rich, graywacke turbidit vith medium-dark-gray, light-olive-brown-weathering slate, calcisiltite, and minor thir beds of conglomerate. The amount of graywacke ranges from 10 to 20 percent with rare instances of 50 percent, particularly near the top of the exposed section, and beds become ick-bedded with rare parallel laminations. Graywacke beds contain abundant fauna lebris. Sedimentary structures in some turbidites obliterated in places by bioturbation Rusty-weathering channels filled with coarse-grained sandstone, abundant shelly fauna and pyrite are common in light-olive-brown-weathering graywackes. Graywacke beds also contain rare clasts of rounded chert. Approximately 1,520 m (5,000 ft) thick. Upper part of unit not present due to faulting and erosion. Unit is structurally and unconfo overlain by the Tuscarora Sandstone (SOt). Lower contact transitional over 15 m (50 ft with underlying New Tripoli Formation (Ont) and is placed where sandstones commonly make up less than 10 percent and beds are less than 5-10 cm (2-4 in) thick New Tripoli Formation (Middle Ordovician)—Medium-dark-gray, light-olive-brownweathering, thin, evenly bedded, calcareous graywacke interbedded with fairly thick slate and calcisiltite beds (as much as 50 cm, or 20 in thick). The calcisiltite beds are most ommonly 2-5 cm (1-2 in) thick and are more resistant to weathering, giving the rock bbed appearance. This characteristic contrasts markedly with the ribbon slate of the ill Member (Omb) of the Martinsburg Formation, which weathers more even Shelly fossil debris is common, especially near the upper contact of the unit, but not abundant. The contact between the Bushkill (Omb) and this unit is not a gradual facies

minimum thickness is 1,500 m (4,900 ft)

change in this area, but is a thrust fault representing significant structural telescoping. Lower contact not exposed because of faulting of both Taconic and Alleghanian age. Approximate

LEBANON VALLEY SEQUENCE This group of rocks is exposed only in a small area at the west edge of the map in Pennsylvania. This sequence has affinities with rocks in the Conestoga Valley of the Piedmont Province, but is distinct from the Lehigh Valley sequence present throughout the Great Valley, in that it is missing the unconformity at the base of the Jacksonburg Limestone (Oj). In addition, the carbonates of the Lebanon Val sequence are generally a slightly deeper water facies of the same units in the Lehigh Valley and Schuyllsequences, and perhaps have travelled a greater distance along northward- or northwestward-movin hrust faults. The rocks of the Lebanon Valley sequence rest structurally on top of the rocks of the Schuvlkill sequence. Only the units not exposed in the Lehigh Valley and Schuvlkill sequences are separately described below. See correlation chart for relations between the three sequences.

Annville Limestone (Middle Ordovician)—Medium-gray, light-gray-weathering, high calcium limestone with thick beds exhibiting wavy bedding. The upper contact is commonly marked by thrust faults and the lower contact is apparently gradational. nickness ranges from 0 to 34 m (0 to 110 ft) Ob Beekmantown Group, undivided (Middle and Lower Ordovician)—Due to the poor exposure of these rocks and the present lack of fossil data, no attempt has been made to Richland Formation of the Conococheague Group (Upper Cambrian)—Medium-gray thick-bedded dolomite and limestone. Limestone beds commonly have silty and sand laminae. Beds commonly contain nodules and stringers of brownish-gray chert and oolitic and cryptozoon layers. Discrete dolomitic sandstone beds are also present. Lower contact is gradational. Unit is only partly exposed and minimum thickness is 530 m (1,700 ft) Millbach Formation of the Conococheague Group (Upper Cambrian)—Light-gray, thick-bedded limestone and lesser dolomite. Thickness is approximately 100 m (330 ft) Buffalo Springs Formation of the Conococheague Group (Upper Cambrian)-Fin grained, light-blue-gray, thickly and massively bedded limestone grading downward into a fine- to medium-grained, light-grav, vellowish- to light-olive-grav-weathering dolomite interbedded with fine- to medium-grained, dirty-white to pinkish-gray to medium-gray limestone, and thin, light-olive-gray-weathering, sandy or silty limestones. In the unit as a whole, limestone is more common than dolomite. The dolomites commonly are algalaminites with occasional cryptozoon structures. Lower contact is gradational with the underlying Zooks Corner Formation (Czc). North of the Newark-Gettysburg basin, a partial section is less than 300 m (1,000 ft) thick; south of the basin in the northern ont it may reach 400 m (1,300 ft)

common ripple-laminated, grayish-blue limestone and medium-bedded, crossbedded andstone. Lower beds overlie and partially interfinger with the Ledger Dolomite (Clg) North of the Newark-Gettysburg basin, a partial section has a thickness of probably less than 100 m (360 ft). South of the basin, in the northern Piedmont, the thickness is 150 Includes rocks of €bs, €zc, €lg, and €k This structurally and stratigraphically complex group of far-travelled rocks is located in the Pennsylvania Great Valley and resembles the Taconic allochthon of New York State. The klippe is divided into two tectonic slices: 1) the Greenwich slice, an accretionary prism of sediments displaying scaly cleavage tha composes the Windsor Township Formation, and 2) the Richmond slice, a sequence of rise and slope deposits that composes the Virginville Formation. Although emplaced by thrust faults during the Taconic

Zooks Corner Formation (Middle (?) Cambrian)—Very fine grained, medium-gray, thin-

thick-bedded, silty to sandy dolomite with common shaly partings interbedded with les

orogeny, these faults have been obscured by later Alleghanian folds and faults. Although the klippe was thrust on the rocks of the Lehigh Valley and Schuylkill sequences in Taconic time, some rocks of the Lehigh Valley and Schuylkill Valley sequences were later thrust on top of the rocks of the Hamburg klippe Windsor Township Formation (Middle and Lower Ordovician) Owd Dreibelbis Member—Medium- to very thick bedded, partly graded, fine- to coarse-grained locally conglomeratic, somewhat calcareous graywacke sandstone interbedded with dat greenish- to light-olive-gray, fissile to poorly cleaved mudstone, siltstone, and shale Characterized by the predominance of partial Bouma (1962) sequences Ta and Tae, with lesser Tb-e, Tc-e, and Td-e sequences. The Dreibelbis has probably been incised into the Weisenberg Member (Oww). Minimum thickness about 1,200 m (3,937 ft) Ows Switzer Creek Member-Medium- to thick-bedded, massive, medium-to coarse-grained to conglomeratic graywacke interbedded with lesser amounts of dark-greenish-gray mudstone and shale. Graywacke is rich in carbonate grains and pebbles, which weather to very distinctive, rotten and porous, limonite-stained rocks. Partial Bouma (1962) sequences Ta and Tae predominate. The Switzer Creek has probably been incised into ne Weisenberg Member (Oww). Minimum thickness about 914 m (3,000 ft) Weisenberg Member—Light-olive-gray to grayish-olive, fissile to poorly cleaved shale and nudstone to micaceous siltstone with minor amounts of medium-dark- to dark-greenishgray, silicified shale, mudstone, and argillite. In some places, thin-bedded siltstone and raywacke sandstone, and debris flows of chert and silicified mudstone are interbedded with the shale and mudstone. Soft-sediment slump folds are common. Local channel contain a very distinctive conglomerate with chalky-white-weathering feldspar grains and rare volcanic rock fragments. This conglomerate is best exposed 0.3 km (0.2 mi) east of

rleys Corner in the Slatedale 7.5-minute quadrangle. Minimum thickness about 1,73 Owc Polymict conglomerate—Light-green to medium-dark-gray and dark-greenish-gray pelitic matrix containing clasts ranging in size from less than a cm to at least 3 m (10 ft). Class lithologies include graywacke, carbonate, siltstone, shale, and chert. All clasts are derived Red beds-Dusky-red, grayish-yellow to light-green, locally silicified mudstone and argillite, interbedded with very thin to thick-bedded siltstone, sandstone, black calcilutite to calcarenite, and chert. Carbonate is found locally as clasts and megaclasts within a matri of varicolored shale and argillite. This unit is found locally within the Dreibelbis (Owd) witzer Creek (Ows), and Weisenberg (Oww) Members. Maximum thickness about 21 Virginville Formation (Middle Ordovician to Upper Cambrian) Moselem Member (Middle Ordovician)-Grayish-black to brown, thin-to thick-bedded nudstone and shale interbedded with dark- to dark-greenish-gray, silicified argillite; minor light-gray to black, thin-bedded, ribbon limestone; black shale; and orange-yellow

weathering dolostone. Minor amounts of thin- to medium-bedded, carbonate-clast the Onux Cave (€vo) and Sacony (€vs) Members, although the only exposed fault Onyx Cave Member (Upper Cambrian)—Gravish-black to medium-light-gray, thin- to thick-bedded calcarenite, peloidal limestone, quartzose limestone, and calcareous quartzite; very thick bedded, structureless carbonate-clast conglomerate, thinly interbedded with black lime, mudstone, and shale to argillaceous ribbon limestone, thinly laminated black shale and dark-yellowish-brown-weathering dolostone. Lower contact conformable with the underlying Sacony Member (£vs), except where this unit has been hrust over the Moselem Member (Ovm). About 90 m (300 ft) thick Sacony Member (Upper Cambrian)—Grayish-olive- to pale-blue-green, locally grayish ed, thick-bedded, structureless, micaceous siltstone and sandstone interbedded with grayish- to pale-blue-green micaceous shale and mudstone. Minor amounts of light-gray o light-green, silicified shale and black mudstone. Lower contact is not exposed. Minimun

JUTLAND KLIPPE

These rocks resemble some of the rocks found within the Greenwich slice of the Hamburg klippe in Pennsylvania. Unlike the Taconic allochthon and Hamburg klippe, which occur on the foreland side of the external massifs of the Berkshires and Reading Prong, the rocks of the Jutland klippe occur on the Otja Jutland klippe lower unit A (Ordovician)—Interbedded red and green shale; silty sandstone; silty shale; pink hematite-stained shale; sandstone; and micritic limestone. found throughout the Jutland klippe, but more rarely in this lower unit) become muc nore common. Lower contact absent due to faulting. Minimum thickness estimated at 11 Jutland klippe upper unit B (Ordovician)—Gray, manganese-bearing shale is abundant and restricted to this upper unit. Also present are interbedded red and green shale, interbedded dolomite and green shale, limestone conglomerate, interlaminated limestone nd shale, interbedded fine-grained sandstone, siltstone and shale, and yellow, red, greer

and gray shales interbedded with chert. Sandstone, siltstone, and sparry and micrit carbonate rocks occur throughout the klippe, but are much more abundant in this uni Ithough graptolites are found in both units, conodonts are found only in this unit. Th Peapack klippe is made up entirely of rocks of this unit. Upper contact not presen Minimum thickness estimated at 90 m (300 ft) FURLONG KLIPPE OF THE BUCKINGHAM VALLEY OUTLIER A small area of Taconic-like rocks is found in the Buckingham Valley Paleozoic-Proterozoic outlier in the middle of the Newark basin. Like the Jutland klippe, these far-travelled rocks occur on the hinterland

side of the Reading Prong external massif. The presence of the Buckingham Valley outlier may be due in part, to pull-apart tectonics that formed local highs or "horsts" through compression during the rmation of this part of the Newark basin and, in part, to earlier folding of Taconic thrust sheets of the nt that put these rocks at the crest of an anticline. Undivided Taconic-like rocks of the Furlong klippe (Cambrian (?))-Fissile to slaty black, blue, purplish and gray phyllite. Minimum thickness is approximately 60 m (200 ft Taconic allochthon rocks, it is very possible that they have been thrust over the nearb Lehigh Valley-like Paleozoic rocks of the Buckingham Valley outlier, much as the Hambur klippe was thrust over the Lehigh Valley sequence to the northwest

PROTEROZOIC ROCKS OF THE READING PRONG

All of the rocks of the Reading Prong are allochthonous and represent an imbricate stack of thrust sheets that have been thrust over the Paleozoic rocks of the Great Valley. These thrusting events probably took place both during Taconic and Alleghanian times and perhaps as a continuum in between, however, most of the movement probably occurred late in the Paleozoic. The Proterozoic rocks have undergone at least one high-grade Proterozoic metamorphism and two low-grade Paleozoic metamorphisms. These rock primarily include the layered sequences of the Losee Metamorphic Suite and of the interlayered calcareous and quartzofeldspathic gneisses. They also include intrusive rocks of the Byram Intrusive Suite and pyroxene granites with related quartz-poor rocks. There is no stratigraphic order for the units given below. For relations among these rocks, see figure 3. Chestnut Hill Formation (Late Proterozoic (?))—Interbedded sequence of arkose, ferruginous quartzite, quartz-pebble conglomerate, sericite-talc-chlorite schist, and metarhyolite. Occurs only locally in several areas near the Delaware River

Pyroxene granite and related quartz-poor rocks (Middle Proterozoic)-A verv ogeneous group of rocks consisting of pyroxene granites ranging in composition from nodiorite to alkali-feldspar granite, and other quartz-poor rocks ranging in composition from monzodiorite to quartz-alkali-feldspar svenite and alkali-feldspar svenite. Fair abundant northwest of the Green Pond syncline in New Jersey. Many of these rock contain what appears to be a primary flow foliation. These rocks differ from the Byran Intrusive Suite by having mesoperthite (largely antiperthitic) as the primary feldspar, higher iron-to-magnesium ratio, and more calcium. Genetic relations with the Byram Intrusive Suite are unknown Byram Intrusive Suite Alaskite, microperthitic and microantiperthitic (Middle Proterozoic)-The nicroperthitic alaskite comprises light-pink to light-gray, medium- to coarse-grained foliated alaskite and gneissoid alaskite composed largely of microperthite, quartz, and

oligoclase. Contains bodies of amphibolite, homblende granite, and potassic-feldspar gneiss that are too small to map. The microantiperthite alaskite differs from t icroperthite alaskite in that the principal feldspar is microantiperthite. This unit weathers chalk white Hornblende granite and associated biotite granite (Middle Proterozoic)-Pink to light gray, medium- to coarse-grained, gneissoid granite, foliated granite, and sparse granite neiss composed principally of microperthite, quartz, oligoclase, homblende and (or biotite. In granite gneiss phases, microperthite has typically recrystallized. Rock contains free microcline and oligoclase. Includes bodies of alaskite, amphibolite, and potassiceldspar gneiss that are too small to map Metasedimentary Layered Sequence

Marble (Middle Proterozoic)—Fine- to medium-grained, white to grayish-white calcite marble and medium-gray, greenish-gray-weathering dolomite marble. Much of the dolomite marble largely altered to serpentine, tremolite, and talc. Probably found at many fferent stratigraphic levels and not confined to one age Biotite-quartz-plagioclase gneiss (Middle Proterozoic)—Light- to medium-dark-gray t pale-yellowish-brown, fine- to medium-grained, well-layered gneiss of variable composition but always containing conspicuous biotite. Some phases contain garnet and) magnetite. Unit differs from oligoclase quartz gneiss (YIo) in its heterogeneity and welldefined layering, and from potassic feldspar gneiss (Ymk) in that most of the feldspar is plagioclase. Also included in this unit are light- to light-greenish- to pin sh-gray, medium grained, well-foliated, strongly migmatitic gneisses containing quartz, microclinenicroperthite, monoclinic potassic feldspar, sericitized oligoclase, and sillimanite Potassic feldspar gneiss (Middle Proterozoic)—Grayish-pink, pinkish-gray, light-gray or light-greenish-gray, fine- to medium-grained gneiss and minor granofels that have poor to fair foliation and are composed largely of quartz, potassic feldspar and minor amounts of interlayers of biotite-quartz-plagioclase gneiss (Ymb) and feldspathic quartzite. In places unit has been partly mobilized to form sheets and irregular bodies of alkali-feldspar granite quartz-rich granitoid Pyroxene gneiss (Middle Proterozoic)—Greenish-gray to light-grayish-green, medium

grained, well-layered to nearly massive, granoblastic gneiss composed principally of diopsidic pyroxene and plagioclase and lesser quantities of homblende, quartz, biotite, and

nagnetite. At some places unit contains relict patches of marble

Losee Metamorphic Suite Ylo Oligoclase-quartz gneiss (Middle Proterozoic)—Light-greenish-gray to grayish-green, medium-fine- to medium-coarse-grained, poorly foliated, granoblastic gneiss and minor granofels. Composed principally of oligoclase and quartz. Minor amounts of biotite, ounts of interlavered amphibolite Albite-oligoclase granite (Middle Proterozoic)—Medium- to coarse-grained, light-green to dull-white, gneissoid granite composed principally of albite, oligoclase, quartz, and minor amounts of sodic homblende, or more rarely augite or magnetite. Rock is thought to be n anatectic phase of oligoclase-quartz gneiss (YIo) Albite pegmatite (Middle Proterozoic)—Light-greenish-gray, or more rarely moderate orange-pink, coarse-grained rock composed principally of albite, quartz and lesser amounts of microperthite. Locally contains masses and large crystals of sodic homblender and, more rarely, pyroxene and magnetite. Some phases are syenitic. Rock is thought to be a coarse-grained phase of the albite-oligoclase granite (YIa)

Hexenkopf Complex Hornblende-augite-quartz-andesine gneiss (Middle Proterozoic)-A strongly seri citized, chloritized, and silicified gneiss containing hornblende, augite, quartz, andesine, and lesser amounts of epidote, biotite, sphene, gamet, apatite, magnetite, pyrite, chlorite, and zircon. In many places it is strongly veined by albite pegmatite (YIp) and microperth alaskite (Yba). Rock is probably a metamorphosed gabbro or diorite. Composes about 60 Epidote-augite-hornblende-plagioclase gneiss (Middle Proterozoic)-Grayish-olive, ense, massive, well-foliated gneiss containing sparse amounts of biotite, sphene, and magnetite, and widely varying amounts of quartz. Rock appears to be a metamorphosed and altered pyroxenite. Composes 25 percent of complex Quartz-garnet-augite granofels (Middle Proterozoic)-Medium-fine- to mediumgrained, equigranular, highly siliceous granofels containing quartz, garnet, augite, and Rocks of Uncertain Origin and Relative Age

Amphibolite (Middle Proterozoic)—Light- to dark-gray to nearly black, fine- to mediumgrained rock composed principally of hornblende and andesine. Some phases contain augite and, more rarely, hypersthene or biotite. Much of rock is probably metavolcanic and Amphibolitic migmatite and related hybrid rocks (Middle Proterozoic)-Mixed rock mposed of irregular knots, lenses, veins, and layers of microperthite alaskite (Yba) ir amphibolite (Ya). In some areas, this rock is a mixture of albite-oligoclase granite (YIa) and amphibolite. Both types of mixed rock are intruded by veined gneiss and permeation gneiss. In the Trenton Prong, that narrow belt of Proterozoic rocks of the northern Piedmont that is found north of the Huntingdon Valley fault, hybrid rocks are, in some places, interlayered amphibolite and a light-colored felsic gneiss, and, in other places are ogenized completely to a felsic gneiss of intermediate composition. In some place the unit is very rich in graphite, contains lenses of marble, and may represent a partial migmatized Pickering Gneiss (Ypgn). Although this unit is found both in the Reading ar renton Prongs, it is likely that the protolith has a larger proportion of igneous rocks in the eading Prong and of sedimentary rocks in the Trenton Prong Quartz diorite (Middle Proterozoic)-Light- to dark-gray, medium- to coarse-grained rock composed principally of andesine or oligoclase, quartz, and hypersthene. Some phases contain augite and (or) biotite. Unit has a charnockitic affinity and is thought to b a partly mobilized, amphibolite-rich phase of oligoclase-quartz gneiss (YIo). Unit contains

small bodies of albite-oligoclase granite (YIa) and amphibolite

THE PIEDMONT PROVINCE The Piedmont is divided into northern and southern parts (see fig. 4). The boundary between the two is the Huntingdon Valley fault south of the Trenton Prong and its unnamed continuation to the west that marks the southern boundary of the Octoraro Phyllite (€Zo). The Proterozoic rocks of the Piedmont are listinctly different in these two regions, suggesting that this fault may represent an important suture. The wo terranes were probably joined before the late Proterozoic or earliest Paleozoic, because the Peters reek Schist (EZpc) occurs on both sides of the extension of this fault in Maryland. In addition netadiabase dikes of possible Late Proterozoic to early Paleozoic age intrude both regions. Both the northern and southern Piedmont are structurally complex, and are characterized by folded and mbricately stacked thrust sheets and duplexes of probable Taconic age. Figure 4 shows stratigraphic and structural relations of Piedmont rocks.

slightly metamorphosed diabase containing augite, plagioclase, and minor hornblend zoisite, and biotite. Intruded after high grade Proterozoic Y metamorphisms, and before lower grade Paleozoic (Taconic) metamorphism. Found to intrude many different Middle Proterozoic gneisses throughout the Piedmont and may intrude both the Peters Creek Schist (€Zpc) and Octoraro Phyllite (€Zo). It is possible that these dikes are roughly th same age as the Catoctin Formation of the central and southern Appalachians Paleozoic and Late Proterozoic Cover Rocks of the Northern Piedmont Many of the Paleozoic cover rocks of the northern Piedmont show distinctive differences in lithology and thickness going from Welsh Mountain and the Barren Hills in the north to the Chester Valley in the

Metadiabase dikes—Fine-grained and more commonly porphyritic, dark-charcoal-gray

These differences are discussed below. Conestoga Limestone (Lower Ordovician to Middle Cambrian)-Upper part consists of medium- to bluish-gray, light-gray-weathering, fine- to medium-grained, thin-bedded (2–10 cm, 1–4 in), highly micaceous limestone with argillaceous, shaly partings parallel to regional cleavage that give the unit a finely laminated appearance. Near the base of the upper part, beds increase in thickness to 25 cm (10 in), and the unit becomes slightly oarser grained. The upper part of the unit has a maximum thickness of 110 m (360 ft but may be partially repeated by faulting. In addition, the upper contact is marked by thrust fault bringing the Octoraro Phyllite (£Zo) over the Conestoga, perhaps truncating part of this unit. The lower part consists of very light gray to white, medium- to coarse grained, medium- to thick-bedded dolomite interbedded with dark-gray to bluish-black a-bedded, medium-grained limestone and dark-gray, fine-grained, thin-bedde dolomite. The lower part has a maximum thickness of 100 m (320 ft), but, like the upper part may be repeated by numerous faults that are difficult to detect. The contact between the upper and lower parts is the locus of significant thrust faulting, which in some areas inserts thin slivers of Octoraro Phyllite (£Zo) within the Conestoga. The lower contact is thought to be an unconformity with the Conestoga overhing the Flyrook Formation (£e) thought to be an unconformity with the Conestoga overlying within the area of this map. However, to the southwest of the mapped area the Con overlies older Cambrian units (specifically, the Ledger Dolomite (£1g), the Kinzers

Formation (€k), and the Antietam Quartzite and Harpers Phyllite (€ah). This supposed conformity may also be the locus of thrusting Elbrook Formation (Upper and Middle Cambrian)-Light-blue, fine-grained, thir bedded limestone which weathers to a shaly, light-yellowish-brown or buff limestone interbedded with cream-colored to pure-white fine-grained thin-bedded laminated lolomitic marble. In the Chester Valley, white marble beds predominate and are thicke here than to the north and west. Concentrations of mica are left as a pressure-solutio residue parallel to regional cleavage. In the Chester Valley, the mica is coarser grained and suggests that the rocks in the southern part of the northern Piedmont are at slightly higher netamorphic grade than the rocks farther north. The lower contact is gradational with the underlying Ledgers Dolomite (£lg); locally, a resistant sandy limestone and chert-rich sandstone at the base makes a good marker horizon. The thickness north of Welsi Mountain is approximately 305 m (1,000 ft), whereas the unit thins to approximately 24 m (800 ft) in the Chester Valley

Ledger Dolomite (Middle Cambrian)—Coarse-grained, white to light- to medium-darkgray, massive, thick-bedded, finely laminated, pure, high-magnesian dolomite with some siliceous beds which weather to rust-stained, granular, cherty layers. In the Chester Valle the dolomite is interbedded with laminated limestone, weathers to a rough granula surface, and is finely speckled in places. The lower part of the unit is characterized b alternating light and dark layering and porous, cherty layers. When the unit is high weathered, it produces a characteristic light-vellow, earthy soil. Upper contact gradatic with the Elbrook Formation (€e) except where overlain by the Conestoga Limestone (O€c). Lower contact is gradational with the Kinzers Formation (€k) in the Chester Valley and with the Vintage Dolomite (€v) north of the Honey Brook uplands. Thickness is pproximately 300 m (1,000 ft) Kinzers Formation (Middle and Lower Cambrian)—The upper part consists of fine-to

nedium-grained, white to light- to medium- to bluish-gray, thin- and irregularly bedded aroillaceous limestone, nodular limestone, and marble lenses surrounded by aroillaceou residue left behind during pressure solution. Marble in some places is mottled ("leopard rock"). Lower part consists of medium-grained, white to light-gray, thin-bedded, impur dolomite that weathers to a buff-yellowish-brown and contains fragments of trilobites. I the Chester Valley, this part is represented by impure limestone that weathers to a shaly mica schist. The lower contact is gradational with the Vintage Dolomite (£v). The thickness north and west of the Barren Hills is 40 m (130 ft) and the thickness is less than 9 m (30 in the Chester Valley Vintage Dolomite (Lower Cambrian)—Upper part is fine- to medium-grained, mottled lue limestone, grading downward into medium-grained, dark-blue, knotty dolomite wit blebs of coarse-grained dolomite, grading downward into medium-grained, gray, thick bedded, glistening dolomite. The lower part is fine-grained, cream-white, thin- to medium bedded, argillaceous to sandy dolomite with mica abundant on bedding planes. This is in gradational contact over 3 m (10 ft) with the underlying ferruginous and calcareous andstone beds at the top of the underlying Antietam Quartzite (Cah). In the north, th thickness of the entire unit is approximately 180 m (600 ft), and in the Chester Valley, the unit is probably less than 60 m (200 ft). Reliable estimates of thickness for this lowest

eozoic carbonate are difficult to make due to poor exposure Elbrook Formation, Ledger Dolomite, Kinzers Formation, and Vintage Dolomit undivided (Cambrian)—Shown in cross section only. Includes units €e, €lg, €k, and Antietam Quartzite and Harpers Phyllite, undivided (Lower Cambrian)—The Antietam is a fine-grained, light-gray, slabby, rusty, laminated quartzite which weathers to a dark-brown manganese-stained soil. Contains Obellella in the rusty layers. It is in gradational contact with the underlying Harpers which is a fine- to medium-grained, greenish- to dark-gray, sandy, argillaceous phyllite. Bedding in the Harpers is almost always impossible to dentify due to pervasive cleavage. In areas where it is possible to map both units th hickness of the Antietam ranges from 140 m (450 ft) in the north to less than 60 m (20 ft) in the south. In the Chester Valley, the maximum thickness is 60 m (200 ft) in the east and the unit is absent in the west. The Harpers ranges from 240 m (800 ft) in the north to less than 150 m (500 ft) in the south Chickies Quartzite (Lower Cambrian)—Upper part consists of medium-grained, gray

massive, crossbedded, medium-bedded, finely laminated, vitreous quartzite with clear quartz grains and fine-grained, variously colored, thin-bedded, sericitic quartz schist. Lower part (commonly referred to as the Hellam Member) consists of a coarse-grained, gray ourmaline-bearing quartzite, arkosic-pebble conglomerate, and interbeds of black slat and biotite schist. This unit rests unconformably and abruptly upon a wide variety of Proterozoic gneisses. The thickness ranges from 400 m (1,300 ft) in the north to less than 130 m (430 ft) in the south. In the Chester Valley the unit is considerably more schistose Octoraro Phyllite* (Cambrian and Late Proterozoic)-Fine- to medium-grained greenish- to silvery-gray, dark-olive-green-weathering phyllite and phyllonite. In some places, abundant white-weathering albite and magnetite grains reach 1 cm (0.25 in) in liameter. Porphyroclasts of albite, magnetite, garnet, tourmaline, rutile, and ilmenite are found in a fine-grained chlorite-muscovite-ribbon quartz matrix. Along the northern edg of the outcrop belt where the Octoraro is thrust over the Conestoga (O cc) it is finer grained contains ilmenite as the dominant oxide mineral (commonly sandwiched between large chlorites), and some very fine grained albite. To the south the albite crystals become large the dominant oxide mineral is magnetite, and the muscovite and chlorite become coarse grained. This suggests that the unit may have undergone a low to medium grade metamorphism, been phyllonitized, and then metamorphosed again at a lower grade. A similar history has been suggested for equivalent rocks along strike to the southwest Maryland. The upper and lower contacts of this unit are marked by major thrust faults. T the north, the Octoraro is thrust over and into the Conestoga along numerous splays o the Martic thrust fault. On the south side an important fault that marks the boundary between the northern and southern Piedmont brings a number of units structurally on to of the Octoraro. These include the Peach Bottom Slate (which crops out as a small fau sliver along the east branch of Octoraro Creek approximately 10 km (6 mi) south of t southwest corner of the Newark 1° x 2° quadrangle), the Peters Creek Schist (€Zpc), the Wissahickon Formation (€Zw), and Proterozoic gneisses. Additionally, there are numerous faults within the unit that make an estimate of thickness impossible. This unit

esembles the Everett Formation in the high-Taconic slices of the Berkshires of New Middle Proterozoic Basement Rocks of the Northern Piedmont These poorly exposed rocks have undergone at least one Proterozoic metamorphism of amphibolite to granulite grade, and a Paleozoic metamorphism of chlorite grade. Metamorphosed igneous rocks are sented by anorthosites and charnockitic gneisses. Metamorphosed sedimentary rocks are represented by graphite-bearing gneisses, marbles, and perhaps some amphibolites. The long narrow pelt of gneisses that lie north of the Huntingdon Valley fault and extend as far east as Trenton, N. J. is referred to here as the Trenton Prong. The Proterozoic rocks of the northern Piedmont have a close affinity to some the rocks of the Reading Prong and the Adirondack massifs.

Pickering Gneiss (Middle Proterozoic)—Medium- to very coarse grained, highly variable gneiss consisting of interlayered quartz-feldspar gneiss, quartz-schist, mica schist, hornblende schist, and calcareous schist and is characterized by the presence of abundant graphite, calc-silicates, and pods of marble. Common accessory minerals are microcline icroperthite, orthopyroxene, calcite, magnetite, pyrite, pyrrhotite, allanite, titanite, zircon scapolite, diopside, and garnet. Rock is commonly deeply weathered and disaggregated Pyrrhotite and pyrite react to form limonite which occurs in such abundance that in pla it has been mined. Intruded by numerous pegmatite dikes ranging in width from 5 cm (2 in) to a meter (3 ft) that are composed primarily of microcline, quartz and abundan graphite. The calcareous schists can contain as much as 16 weight percent graphite, which s easily mined due to the highly weathered nature of the rock: marble lenses are associa ith the graphite-rich horizons. Although the marble can be found throughout the ickering, it appears that most marble lenses occur near the contact between the Pick and the granulite gneisses (Ygg). If the granulite gneisses are older and underlie the Pickering, as implied in the correlation chart, this would place most of the marble near the base of the Pickering. This unit, which is probably a metamorphosed sedimentary sequence, is metamorphosed to the granulite grade of metamorphism north of the Brandywine Manor thrust fault, and to the amphibolite facies south of the fault Marble (Middle Proterozoic)—Discontinuous lenses of coarse-grained, white marble with mificant accessory graphite occurring both as individual grains and as concentrated chlieren parallel to the regional schistosity. Occurs throughout the Pickering Gneiss (Ypgn), but appears to be concentrated near the contact between the Pickering and the granulite gneisses (Ygg). If the Pickering is younger and sits on top of the granulite gneisses, en marble is concentrated in the lower part of the Pickering Amphibolite (Middle Proterozoic)—Medium- to coarse-grained, very dark gray to black, nblende-plagioclase schist and gneiss that can contain as much as 5 percen ppersthene and accessory magnetite, epidote, zircon, pyrite and, in many cases, abunda sphene. Because of its wide-ranging association with the Pickering (Ypgn), amphibolitic migmatite (Ymg), leucocratic gneisses (Ylg), and marble (Ym), it is highly likely that this unit has at least two different protoliths, one that is sedimentary and generally associated with calcareous schists and gneisses, and another that is igneous and associated with both netaplutonic and metavolcanic rocks Amphibolitic migmatite and related hybrid rocks (Middle Proterozoic)—Schists and neisses ranging in composition from felsic to intermediate to mafic, but with the largest

degrees; lenses of fine- to coarse-grained marble; coarse- to extremely coarse grain amphibolites containing as much as 50 percent almandine; plagioclase amphibolites with a trace to 5 percent hypersthene, and medium-grained, biotite-blue quartz-oligoclase-garnet-layered gneiss. Clearly some, but probably not all, of these rocks represent the Pickering Gneiss (Ypgn) and related amphibolites and marbles that have been migmatized and injected with a felsic magma. Makes up most of the Trenton Prong Leucocratic and intermediate felsic gneisses (Middle Proterozoic)—Fine- to mediumgrained, white to light- to medium-dark-gray, microcline-microperthite-quartz gneiss with minor homblende, magnetite, and biotite intimately associated with biotite-oligoclasemicroperthite-quartz gneiss. This unit is interlayered with amphibolite at all scales. Found both north and south of the Brandywine Manor thrust fault at both amphibolite- and granulite-facies metamorphism. Probably a metamorphosed felsic volcanic o volcaniclastic rock. May be roughly equivalent in age with Pickering Gneiss (Ypgn) and younger than Honey Brook anorthosite (Yha) and related charnockitic granulite gneisses Honey Brook anorthosite (Middle Proterozoic)—A large, poorly exposed, elliptically zoned body of anorthosite ranging from anorthosite in the center through dioritic anorthosite, anorthositic diorite, and a layered diorite. The mafic component, primarily

hornblende, magnetite, apatite, and biotite. Although the Honey Brook anorthosite and he leucocratic and intermediate gneisses (YIg) are both light colored and, in some place similar in composition, the leucocratic and intermediate gneisses in contrast, have a texture that varies from granoblastic to lepidoblastic. Occurs entirely within the granulite facies of etamorphism. Locally intruded by coarse-grained, light-gray, microcline perthite-quartzplagioclase pegmatite with accessory hornblende, biotite, garnet, and magnetite. ranulite gneisses (Middle Proterozoic)-Rocks of charnockitic characteristics issociated with and probably intruded by the Honey Brook anorthosite (Yha). Coarse grained, leucocratic to slightly melanocratic commonly layered, mesoperthite-plagioclase ornblende-biotite (potassium feldspar, clinopyroxene, hypersthene, garnet and sillimanite). Exposed north of the Brandywine Manor thrust fault, except for a small area centered 1 mile (1.6 km) west-northwest of Chester Springs, Penn., where it is exposed in a small tectonic window completely surrounded by amphibolite grade rocks. The

Paleozoic and Late Proterozoic Cover Rocks of the Southern Piedmont Most of these rocks are highly deformed mélanges containing exotic blocks of altered mafic and ultramafic rocks, which may, in some cases, represent dismembered ophiolites. These rocks probably range in age from late Proterozoic to earliest Paleozoic. They are definitely older that the regional schistosity, which is presumed to be of Taconic age everywhere. The Swarthmore Granodiorite is probably an igneous rock associated with the Taconic metamorphic event and is included below for

replacement textures such as myrmekite, perthite, anti perthite, corroded quartz, and the formation of mica-quartz and epidote-quartz symplectites in contact with microcline and quartz. However, a thrust fault brings the Wissahickon south over the granodiorite further omplicating the relations between these units Wissahickon Formation* (Cambrian and Late Proterozoic)—Fine- to medium-grained medium- to dark-gray to black, brownish-gray to slightly rusty weathering, aluminous, pelitic schist, feldspathic metagraywacke with thin interbedded amphibolites, and lenses and pods of altered ultramafic rocks. Rocks range in metamorphic grade from greenschist through upper amphibolite facies, including partial melting producing migmatites. Where the unit is exposed in thin fault slivers between the Cream Valley fault and the fault contact on the south side of the Octoraro Phyllite (€Zo), it is a highly crenulated, coarse-grains gamet-mica schist. Southeast toward the type sections along Wissahickon Creek in Philadelphia the metamorphic grade increases and the percentage of feldspathic netagraywacke increases. In south part of map area the unit becomes gneissic. Contact with the Swarthmore Granodiorite (Osg) within the map area is a thrust fault (probably

a back-thrust) bringing the Wissahickon south over the granodiorite Peters Creek Schist (Cambrian and Late Proterozoic)—A flyschoid sequence of metagraywacke, metasemipelite and pelite rich in quartz and magnetite. The metagraywacke is fine to medium grained, light to medium gray, yellowish- to reddishprown weathering, well-bedded with graded beds and parallel laminations recognizable in places. The metasemipelite is fine to medium grained, light to medium gray, reddish brown weathering schist and gneiss. The metapelite is fine grained, lustrous, greenish gray to gray, sedimentary facing indicators and sense of rotation of minor folds, it is possible that the entire outcrop belt of the Peters Creek on this map is upside down. Thickness estimate is mpossible due to faulting and incomplete section. Contains tectonic slivers of altered

erpentinite (Cambrian and Late Proterozoic)—Tectonic lenses, pods, and slivers of erpentinite with abundant actinolite and chlorite. Highly sheared rocks that preserve few original igneous textures. These tectonic lenses are found within the Member C of the Manhattan Schist (CZmc) and the Wissahickon Formation (CZw), but are present in greater abundance east of Cameron's Line (the unnamed thrust fault that wraps around aten Island on the east side of the Newark 1° x 2° quadrangle) in the Hartland terran of Westchester County, N.Y. and western Connecticut. Although none of the rocks associated with the serpentinite bodies east of Cameron's Line are found within the map area, a very large serpentinite body underlies much of Staten Island. Many of these serpentinite bodies have probably been depositionally included in the surrounding edimentary rocks after their tectonic inclusion along numerous shear planes and thrus Amphibolite (Cambrian and Late Proterozoic)-Fine-to coarse-grained, "salt and

pepper"-textured, hornblende-plagioclase-epidote rock with minor magnetite in discontinuous layers, lenses and pods commonly parallel to cleavage and, in some places, EZpc), and Member C of the Manhattan Schist (€Zmc). Protolith may be intrusive sills Member C of the Manhattan Schist of Hall (1976) (Cambrian to Late Proterozoic)-Fine- to medium-grained, medium-dark-gray to black, brown- to brownish-gray- and rusty-weathering feldspathic sillimanite-garnet-muscovite-biotite schist and layered gneis with lesser siliceous schist, thin metaguartzite, metagravwacke, and amphibolite. Alway well-foliated, with bedding difficult to recognize. In some places contains large sills of amphibolite and lenses of serpentinite. Thickness perhaps as much as 1,600 m (5,200 ft), but estimates are difficult because of incomplete section due to faulting

Middle Proterozoic Basement Rocks of the Southern Piedmont All rocks in the West Chester Prong have been metamorphosed to granulite grade during the Proterozoic and to a high grade during the Taconic. The rocks described below display significant variation from west to east in the West Chester Prong, and are therefore subdivided into an eastern and western facies. Although most of the map area falls in the eastern end of the West Chester Prong, both facies are described. Immediately south of the mapped area these same rocks have been retrograded to amphibolite grade.

Aluminous quartzites (Middle Proterozoic)—These rocks are found only in the western end of the West Chester Prong and only in one small pod at the south edge of this map. They are coarse grained, primarily kyanite-quartz-garnet rocks with accessory phlogopia plagioclase, orthoclase, fine perthite, and occasional rutile, graphite, zircon, and zinc-rich spinel and staurolite. Kyanite can be as much as 40 percent of the rock and generally occurs as aggregates. In some places, however, the rocks become garnet-quartz granulites with accessory zircon. Both the kyanite- or garnet-rich, quartzose rocks contain very little alkalies. They may either represent the restite left after partial melting of a quartz-rich ediment or may be metamorphosed clay deposits roxene granulites (Middle Proterozoic)-In the eastern end of the West Chester rong, these hypersthene-salite-plagioclase granulites are medium grained, faintly foliate

and have equigranular granoblastic textures and digrite to gabbro composition. Plagioclass is commonly antiperthitic, and very low in potassium. Accessories consist of magnetite and(or) ilmenite, zircon, and apatite. In the western end of the West Chester Prong, thes rocks differ by having no foliation and, in places, by containing homblende in addition to the two pyroxenes. Also, there are 1-10 cm (0.5-4 in) lenses of coarse-grained pyroxenite containing 90 percent hypersthene and 10 percent salite. The protoliths for these rocks are nost likely a series of mafic and ultramafic igneous rocks, perhaps olivine basalts or gabbros uartzofeldspathic granulites (Middle Proterozoic)—In the eastern end of the West ter Prong, these rocks are coarse grained, dark colored, quartz-potassium-feldspargarnet-biotite granulites with occasional clinopyroxene and hornblende, that are high variable in mineralogy and composition. They contain a conspicuous lineation marked streaks of mafic minerals. In the western end of the West Chester Prong, these granulite contain much more quartz (as much as 50 percent), are finer grained, lighter in color, and have more abundant potassium feldspar in the form of coarse mesoperthite, which is present in roughly equal amounts to plagioclase. The second metamo garnet coronas between plagioclase and mafic minerals. To the south of the map area. hese rocks underwent extensive recrystallization at amphibolite grade. The protoliths for these rocks are most likely sedimentary, perhaps quartz-rich graywackes, with or without a volcaniclastic component

 The Brunswick Formation as originally defined by Kümmel (1897) is raised in rank to the Brunswick Group and is revised to include the the Watchung Basalt of Darton (1890), which is herein abandoned Olsen (1980a, b) divided these rocks into seven formations in New Jersey, which are, from youngest to oldest, the Boonton Formation, Hook Mountain Basalt, Towaco Formation, Preakness Basalt, Feltville ormation, Orange Mountain Basalt, and Passaic Formation. The Orange Mountain Basalt through the Boonton Formation, as well as the Jacksonwald Basalt in Pennsylvania, are herein accepted for use by the U.S. Geological Survey. The Passaic Formation of Olsen (1980a) has enough textural differences etween its type section in northeastern New Jersey and its outcrops in Pennsylvania that the Pennsylvania Geological Survey has not accepted that name. Likewise, the use of the Passaic Formation in western New Jersey is open to question. Several varieties of conglomerates, whose stratigraphic positions are not entirely clear, are listed separately from the units of the Brunswick Group Jacksonwald Basalt near Reading, Penn., is probably the same flow as the Orange Mountain Basalt, a the strata overlying the Jacksonwald (the upper part of the Brunswick Group) correlate with the Feltville nation of New Jersey. Figure 1 shows the regional stratigraphic relations for the Newark and Gettysburg basins in the Newark 1° x 2° quadrangle. The name Wissahickon Formation herein applies only to those rocks included in the original definition the Wissahickon mica gneiss (Bascom and others, 1909). This includes the type section in the adelphia area between Chestnut Hill and Manayunk, as well as the narrow, fault-bounded, slivers) The name Octoraro Schist of Bascom (1909) is herein reinstated for use by the U. S. Geological Survey and is changed to Octoraro Phyllite. The assignment of the Cambrian-Laté Proterozoic age is based on nal correlations with similar rocks in the high-Taconic slices of the Berkshires of Massachusetts (e. the Everett Formation) and the fact that these rocks rest in structural (not depositional) contact on the underlying Conestoga Limestone of probable Ordovician-Cambrian age. These rocks are not part of the

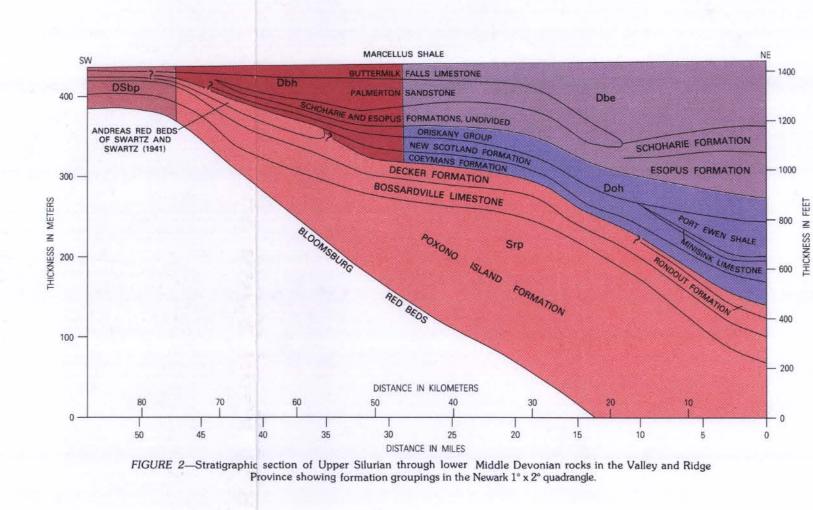
EXPLANATION OF MAP SYMBOLS

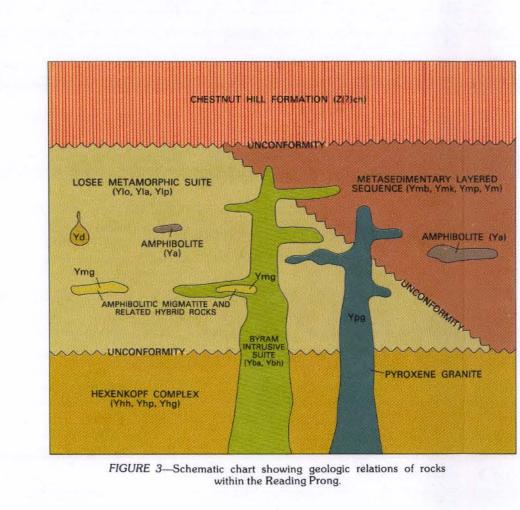
Thrust fault—Teeth on hanging wall. Dashed where inferred; dotted where concealed; queried where uncertain Normal fault—U, upthrown side; D, downthrown side Anticline—Showing trace of axial surface

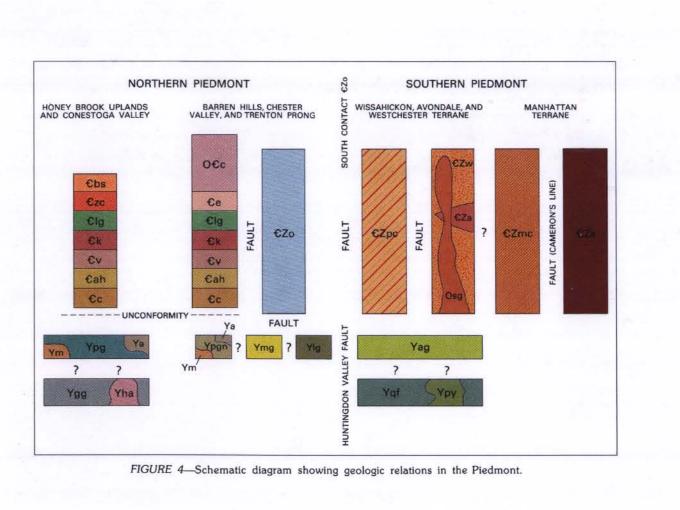
Syncline—Showing trace of axial surface

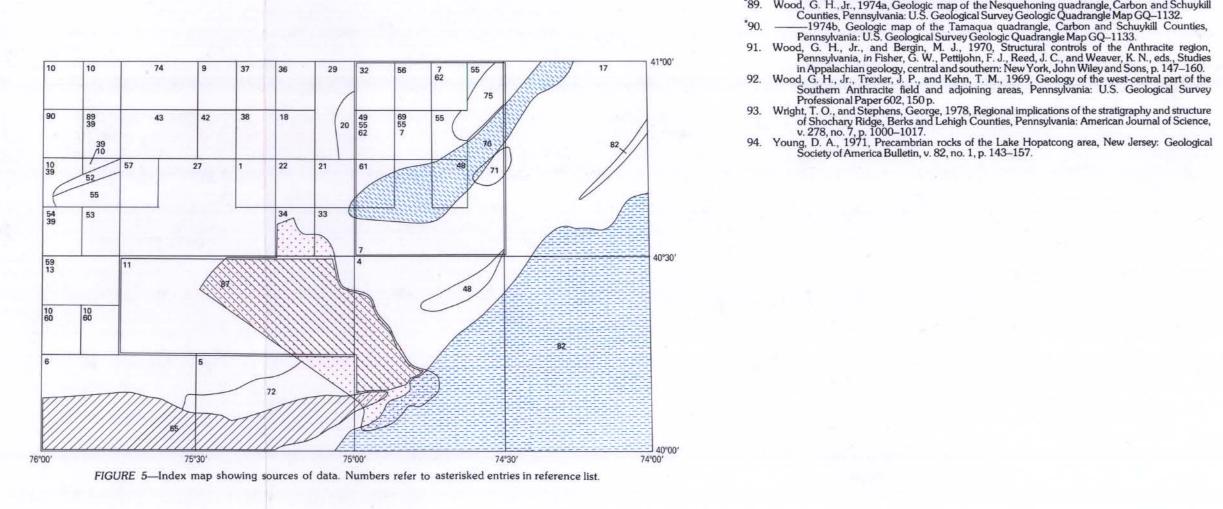
kon Formation as assumed by many workers.

FIGURE 1—Correlation diagram for the Newark and Gettysburg Basins.









 Aaron, J. M., 1971, Geology of the Nazareth quadrangle, Northampton County, Pennsylvania: U.S. Geological Survey Open-File Report 75–92, 353 p.
 Armstrong, E. J., 1941, Mylonization of hybrid rocks near Philadelphia, Pennsylvania: Geological Society of America Bulletin, v. 52, no. 5, p. 667–693.

3. Baker, D. R., and Buddington, A. F., 1970, Geology and magnetite deposits of the Franklin Professional Paper 638, 73 p.
4. Bascom, Florence, Clark, W. B., Darton, N. H., Kümmel, H. B., Salisbury, R. D., Miller, B. L. * 5. Bascom, Florence, Darton, N. H., Kümmel, H. B., Clark, W. B., Miller, B. L., and Salisbury, F. 6. Bascom, Florence, and Stose, G. W., 1932, Coatesville and West Chester, Pennsylvania emponent being intermediate in composition. Contains a great variety of rock type including medium- to very coarse grained, graphitic schists that are migmatized to varying Survey Geologic Atlas, Folio 191, 32 p.

8. Behre, C. H., Jr., 1927, Slate in Northampton County, Pennsylvania: Pennsylvania Geologica Berlie, C. H., 1827, State in Northampton County, Perinsylvania. Perinsylvania Geological Survey, 4th Series, Bulletin M9, 308 p.
 Berg, T. M., 1975, Geology of the Brodheadsville quadrangle, Monroe and Carbon Counties, Pennsylvania: Pennsylvania Geological Survey, 4th series, Atlas 205a, 60 p.
 Berg, T. M., and Dodge, C. M., compilers, 1981, Atlas of preliminary geologic quadrangle maps Buckwalter, T. V., 1962, The Precambrian geology of the Reading 15-minute quadrangle: Pennsylvania Geological Survey, 4th series, Progress Report 161, 49 p.
 Chadwick, G. H., 1908, Revision of "the New York series": Science, v. 28, no. 5, p. 346–348.
 Crawford, W. A., Robelen, P. G., and Kalmbach, J. H., 1971, The Honey Brook anorthosite: he rim. The entire body displays a hypidiomorphic texture and contains plagioclase inferred fault framing this window is shown on cross section A-A' as the Brandywine Swarthmore Granodiorite (Ordovician)—Microcline-oligoclase-quartz-biotite-muscovite gneiss with accessory epidote, sphene, and apatite. The contact between the Wissahickon Formation (£Zw) and the Swarthmore is characterized by a series of

 Davis, R. E., Drake, A. A., Epstein, J. B., 1967, Geologic Audrangle, Pennsylvania, New Jersey-New York: U.S. Geological Survey Geologic Atlas, Folio 157, 27 p.
 Davis, R. E., Drake, A. A., Epstein, J. B., 1967, Geologic map of the Bangor quadrangle, Pennsylvania-New Jersey: U.S. Geological Survey Geologic Quadrangle Map GQ-685.
 Dermon, F. E., III, 1977, Investigations of the origins and metamorphic history of Precambrian gneisses, Downington 7.5-minute quadrangle: Bryn Mawr, Pennsylvania, Bryn Mawr College, unpublished M.A. thesis, 77 p. Drake, A. A., Jr., 1965, Carbonate rocks of Cambrian and Ordovician age, Northampton and Bucks Counties, eastern Pennsylvania, and Warren and Hunterdon Counties, western New Jersey: U.S. Geological Survey Bulletin 1194–L, p. L1–L7. -1967a, Geologic map of the Bloomsbury quadrangle, New Jersey: U.S. Geological Survey Geologic Quadrangle Map GQ-595. ——1967b, Geologic map of the Easton quadrangle, New Jersey-Pennsylvania: U.S. Geological Survey Geologic Quadrangle Map GQ-594. -1969, Precambrian and lower Paleozoic geology of the Delaware Valley, New Jersey Pennsylvania, field trip I-A, in Subitzky, Seymour, ed., Geology of selected areas in New Jersey and eastern Pennsylvania and guidebook of excursions: New Brunswick, New Jersey, —1970, Structural geology of the Reading Prong, in Fisher, G. W., Pettijohn, F. J., Reed, C., and Weaver, K. N., eds., Studies of Appalachian geology, central and southern: New York John Wiley and Sons, p. 271–291.

——1978, The Lyon Station-Paulins Kill nappe—The frontal structure of the Musconetcon nappe system in eastern Pennsylvania and New Jersey: U.S. Geological Survey Professiona Paper 1023, 20 p.
——1984, The Reading Prong of New Jersey and eastern Pennsylvania—An appraisal of rock relations and chemistry of a major Proterozoic terrane in the Appalachians, in Bartholomew, M. J., ed., The Grenville event in the Appalachians and related topics: Geological Society of America Special Paper 194, p. 75-109. Drake, A. A., Jr., and Epstein, J. B., 1967, The Martinsburg Formation (Middle and Upper Ordovician) in the Delaware Valley, Pennsylvania-New Jersey: U.S. Geological Survey Bulletin 1244-H, p. H1-H16. Drake, A. A., Jr., Epstein, J. B., and Aaron, J. M., 1969, Geologic map and sections of parts of the Portland and Belvidere Quadrangles, New Jersey-Pennsylvania: U.S. Geological Survey Miscellaneous Investigations Series Map 1-552. Drake, A. A., Jr., Kastelic, R. L., Jr., and Lyttle, P. T., 1984, Geologic map and sections of parts of the Portland and Belvidere quadrangles, New Jersey: U. S. Geological Survey Miscellaneous Investigations Series Map I–1530.

Drake, A. A., Jr., and Lyttle, P. T., 1980, Alleghanian thrust faults in the Kittatinny Valley, New Jersey, in Manspeizer, Warren, ed., Field studies of New Jersey geology and guide to field trips: Newark, New Jersey, Rutgers University Press, p. 92–114. 1985, Geologic map of the Blairstown quadrangle, Warren County, New Jersey: U.S. Geological Survey Geologic Quadrangle Map GQ-1585.

B. Drake, A. A., Jr., McLaughlin, D. B., and Davis, R. E., 1961, Geology of the Frenchtown quadrangle, New Jersey-Pennsylvania: U.S. Geological Survey Geologic Quadrangle Map -1967, Geologic map of the Riegelsville quadrangle, Pennsylvania-New Jersey: U.S. Drake, A. A., Jr. and Morgan, B. A., 1981, The Piney Branch Complex—A metamorphosed fragment of the Central Appalachian ophiolite in northern Virginia: American Journal of Science, v. 281, no. p. 484-508. Epstein, J. B., 1973, Geologic map of the Stroudsburg quadrangle, Pennsylvania-New Jersey: U.S. Geological Survey Geologic Quadrangle Map GQ-1047.

— in press, Geologic map of the Saylorsburg quadrangle, Pennsylvania: U.S. Geological Survey Geologic Quadrangle Map GQ–1638.

— in press, Geologic map of the Wind Gap quadrangle, Pennsylvania: U.S. Geological Survey Epstein, J. B., and Epstein, A. G., 1969, Geology of the Valley and Ridge Province between Delaware Water Gap and Lehigh Gap, Pennsylvania, field trip 1-B, in Subitzky, Seymour ed., Geology of selected areas in New Jersey and eastern Pennsylvania and guidebook of excursions: New Brunswick, New Jersey, Rutgers University Press, p. 132-205 1972, The Shawangunk Formation (Upper Ordovician (?) to Middle Silurian) in eastern Pennsylvania: U.S. Geological Survey Professional Paper 744, 45 p.
2. Epstein, J. B., and Sevon, W. D., 1978, Preliminary geologic map and sections of the Kunkletowr quadrangle, Pennsylvania: U.S. Geological Survey Open-file Report 78–392.

*43. Epstein, J. B., Sevon, W. D., Glaeser, J. D., 1974, Geology and mineral resources of the Lehighton and Palmerton quadrangles, Carbon and Northampton Counties, Pennsylvania: Pennsylvania Geological Survey Atlas 195 c and d, 460 p.

44. Froelich, A. J., and Olsen, P. E., 1984, Newark Supergroup, a revision of the Newark Group in North America, in Contributions to stratigraphy: U.S. Geological Survey Bulleti 1537-A n A55-A58. Glaeser, J. D., 1966, Provenance, dispersal, and depositional environments of Triassic sediments in the Newark-Gettysburg Basin: Pennsylvania Geological Survey, 4th series, Bulletin G43. 6. Hague, J. M., Baum, L., Herrman, L. A., and Pickering, R. J., 1956, Geology and structure of the anklin-Sterling area, New Jersey: Geological Society of America Bulletin, v. 67, no. 4, p Hall, Leo M., 1976, Preliminary correlation of rocks in southwestern Connecticut, in Page, L. R Contributions to the stratigraphy of New England: Geological Society of America Memoir loughton, H., unpublished data. Kastelic, R. L., Jr., 1980, Precambrian geology and magnetite deposits of the New Jersey Highlands in Warren County, New Jersey: U.S. Geological Survey Open-file Report 80–78 Kümmel, H. B., 1897, The Newark System; report of progress: New Jersey Geological Survey.

Annual Report of the State Geologist, 1896, p. 25–88.

Kümmel, H. B., and Weller, Stuart, 1902, The rocks of the Green Pond Mountain region: New Jersey Geological Survey, Annual Report of the State Geologist, 1901, p. 1–51.

Lash, G. G., 1978, The structure and stratigraphy of the Pen Argyl Member of the Martinsburg Formation in Lehigh and Berks Counties, Pennsylvania: U.S. Geological Survey Open-file Report 78–391, 225 p. -1985, Geologic map of the Kutztown quadrangle, Pennsylvania: U.S. Geological Survey in press, Geologic map of the Hamburg quadrangle, Pennsylvania: U.S. Geological Survey Lyttle, P. T., and Drake, A. A., Jr., unpublished data.
Lyttle, P. T., Lash, G. G., and Epstein, J. B., 1986, Bedrock geologic map of the Slatedale quadrangle, Pennsylvania: U.S. Geological Survey Geologic Quadrangle Map GQ-1598.

MacLachlan, D. B., 1967, Structure and stratigraphy of the limestones and dolomites of Dauphin County, Pennsylvania: Pennsylvania Geological Survey, 4th series, Bulletin G44, 168 p 1979, Geology and mineral resources of the Temple and Fleetwood quadrangles, Berks County, Pennsylvania: Pennsylvania Geological Survey, Atlas 187ab, 71 p.

—1983, Geology and mineral resources of the Reading and Birdsboro quadrangles, Berks County, Pennsylvania: Pennsylvania Geological Survey, Atlas 187cd. New Jersey Geological Survey, 1973, Geologic overlay of topographic sheet 22: Trenton, N.J. nt of Conservation and Economic Development.

Olsen, P. E., 1980a, The latest Triassic and Early Jurassic Formations of the Newark Basin (eastern North America, Newark Supergroup)—Stratigraphy, structure and correlation: New Jersey Academy of Science, The Bulletin, v. 25, p. 25–51. -1980b, Triassic and Jurassic formations of the Newark basin, in Manspeizer, Warren, ed Field studies of New Jersey geology and guide to field trips: Newark, New Jersey, Rutgers Owens, J. P., and Sohl, N. F., 1969, Shelf and deltaic paleoenvironments in the Cretaceous Tertiary formations of the New Jersey Coastal Plain, in Subitzky, Seymour, ed., Geology of selected areas in New Jersey and eastern Pennsylvania and guidebook of excursions: New Brunswick, New Jersey, Rutgers University Press, p. 235–278. Perry, W. J., Jr., 1978, Sequential deformation in the Central Appalachians: American Journal of Science, v. 278, no. 4, p. 518

–542. 67. Postel, A. W., 1940, Hydrothermal emplacement of granodiorite near Philadelphia: Proceedings of the Academy of Natural Science of Philadelphia, v. 92, p. 123–152.
—1951, Problems of the pre-Cambrian in the Phoenixville and Honey Brook quadrangles, Chester County, Pennsylvania: Pennsylvania Academy of Science, v. 25, p. 113–119.

69. Quick, A. N., 1960, Structural geology of the Hackettstown 7.5-minute quadrangle, New Jersey: New York, New York University, unpublished M.S. thesis, 50 p.

70. Ratcliffe, N. M., 1980, Brittle faults (Ramapo fault) and phyllonitic ductile shear zone in the basement rocks of Ramapo seismic zone, New York and New Jersey, and their relationship to current seismicity, in Manspeizer, Warren, ed., Field studies of New Jersey geology and uide to field trips: Newark, New Jersey, Rutgers University Press, p. 278-312 tcliffe, N. M., unpublished data. Rima, D. R., Neisler, Harold, and Longwill, Stanley, 1962, Geology and hydrology of the Stockton Formation in southeastern Pennsylvania: Pennsylvania Geological Survey, 4th series, Groundwater Report W14, 111 p. Sevon, W. D., 1969, Sedimentology of some Mississippian and Pleistocene deposits of

northeastern Pennsylvania, in Subitzky, Seymour, editor, Geology of selected areas in New Jersey and eastern Pennsylvania: New Brunswick, New Jersey, Rutgers University Press, p. —1975, Geology and mineral resources of the Christmans and Pohopoco Mountain quadrangles, Carbon and Monroe Counties, Pennsylvania: Pennsylvania Geological Survey, 5. Sims, P. K., 1958, Geology and magnetite deposits of the Dover District, Morris County, New Jersey: U.S. Geological Survey Professional Paper 287, 162 p. Smith, B. L., 1969, The Precambrian geology of the central and northeastern parts of the New Jersey Highlands, in Subitzky, Seymour, ed., Geology of selected areas in New Jersey and eastern Pennsylvania and guidebook of excursions: New Brunswick, New Jersey, Rutgers Southwick, D. L., 1970, Structure and petrology of the Harford County part of the Baltimore-State Line gabbro-peridotite complex, in Fisher, G. W., Pettijohn, F. J., Reed, J. C., and Weaver, K., N., eds., Studies of Appalachian geology, central and southern: New York, John Wiley Spencer, A. C., and Kümmel, H. B., Wolff, J. E., Salisbury, R. D., and Palache, Charles, 1908. ranklin Furnace, New Jersey: U.S. Geological Survey Geologic Atlas, Folio 161, 27 p. 79. Stose, G. W., 1908, The Cambro-Ordovician limestones of the Appalachian Valley in southern Pennsylvania: Journal of Geology, v. 16, p. 698–714. 1977, Geophysical investigation of the structural framework of the Newark-Gettysburg Triassic basin, Pennsylvania: Geological Society of America Bulletin, v. 88, no. 81. Swartz, C. K., and Swartz, F. M., 1941, Early Devonian and late Silurian formations of southeastern Pennsylvania: Geological Society of America Bulletin, v. 52, no. 8, p. 1129–1191.
 U.S. Geological Survey, 1967, Engineering geology of the Northeast Corridor, Washington, D.C., to Boston, Massachusetts—Coastal Plain and surficial deposits: U.S. Geological Survey Miscellaneous Geologic Investigations Series Map I–514–B.

83. Van Houten, F. B., 1969, Late Triassic Newark Group, north central New Jersey and adjace Pennsylvania and New York, in Subitzky, Seymour, ed., Geology of selected areas in New Jersey and eastern Pennsylvania and guidebook of excursions: New Brunswick, New Jersey,

Rutgers University Press, p. 314-347. 1980, Late Triassic part of Newark Supergroup, Delaware River Section, west-central New Jersey, in Manspeizer, Warren, ed., Field studies of New Jersey geology and guide to field trips: Newark, New Jersey, Rutgers University Press, p.264–276.

Wagner, M. E., and Crawford, M. L., 1975, Polymetamorphism of the Precambrian Baltimore Gneiss in southeastern Pennsylvania: American Journal of Science, v. 275, no.6, p. 653–682.

86. Wherry, E. T., 1910, Contributions to the mineralogy of the Newark Group in Pennsylvania. Wagner Free Institute of Science, Transactions, v. 7, p. 5–27.

87. Willard, Bradford, and others, 1959, Geology and mineral resources of Bucks County, 88. Wise, D. V., 1970, Multiple deformation, geosynclinal transitions and the Martic problem in Pennsylvania, in Fisher, G. W., Pettijohn, F. J., Reed, J. C., and Weaver, K. N., eds., Studies of Appalachian geology, central and southern: New York, John Wiley and Sons, p. 317–333.

89. Wood, G. H., Jr., 1974a, Geologic map of the Nesquehoning quadrangle, Carbon and Schuykill Counties, Pennsylvania: U.S. Geological Survey Geologic Quadrangle Map GQ-1132. You and Schuykill Counties, Pennsylvania: U.S. Geological Survey Geologic Quadrangle Map GQ=1132.
 — 1974b, Geologic map of the Tamaqua quadrangle, Carbon and Schuykill Counties, Pennsylvania: U.S. Geological Survey Geologic Quadrangle Map GQ=1133.
 Wood, G. H., Jr., and Bergin, M. J., 1970, Structural controls of the Anthracite region, Pennsylvania, in Fisher, G. W., Pettijohn, F. J., Reed, J. C., and Weaver, K. N., eds., Studies in Appalachian geology, central and southern: New York, John Wiley and Sons, p. 147–160.
 Wood, G. H., Jr., Trexler, J. P., and Kehn, T. M., 1969, Geology of the west-central part of the Southern Anthracite field and adjoining areas. Pennsylvania: LLS. Geological Survey.

rofessional Paper 602, 150 p.

Southern Anthracite field and adjoining areas, Pennsylvania: U.S. Geological Surve

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